REPORT

OF THE

Agricultural Research Institute and College, Pusa

(*Including the Report of the Imperial Cotton Specialist*)

1912-13

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1914

Price 7 annas or 8d.

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REPORT OF THE DIRECTOR

(JAMES MACKENNA, M.A., I.C.S.)

I.—CHARGE AND STAFF.

Charge.—Mr. Bernard Coventry, who was, on the 14th June 1912, appointed a Companion of the Most Eminent Order of the Indian Empire, held charge of the office of Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, up to the 6th March 1913, when he proceeded on ten months' combined leave, and I was appointed to officiate for him.

Mr. A. C. Dobbs, Assistant to the Agricultural Adviser to the Government of India, returned on the 4th November 1912 from the six months' combined leave granted to him.

Staff.—The Chemical Section remained in charge of Dr. J. Walter Leather, V.D., Ph.D., F.I.C., throughout the year.

Mr. H. E. Annett, B.Sc., M.S.E.A.C., F.C.S., Supernumerary Agricultural Chemist, continued to officiate as Agricultural Chemist, Punjab, until 13th November 1912, when he proceeded on two months and 15 days' privilege leave combined with study leave for ten months and four days. The study leave was granted to enable him to

take a course in Biological Chemistry at Cambridge University or some other institution and visit Agricultural Experiment Stations in England and Germany in order to keep in touch with the most recent work, and incidentally to improve his knowledge of German.

Mr. A. Howard, M.A., A.R.C.S., F.L.S., held charge of the Botanical Section up to the 28th April 1913, when he proceeded on six months' combined leave. Mrs. Howard, M.A., his Personal Assistant, accompanied him. From 8th May to 26th September 1912, Mr. and Mrs. Howard were, as in the previous two years, at Quetta in connection with the development of the Fruit Industry in Baluchistan, an arrangement the continuation of which for a further period of three years (*i.e.*, up to the end of 1916) has been sanctioned by the Secretary of State for India. During their absence, the Second Assistant of the section has held charge of current duties at Pusa and the Third Assistant of the current duties at Quetta. During the year under report, Mrs. Howard was awarded the *Kaisar-i-Hind* Medal of the First Class for public service in India.

Dr. E. J. Butler, M.B., F.L.S., resumed charge of the Mycological Section on his return from privilege leave on July 7th, 1912.

Mr. F. J. F. Shaw, B.Sc., A.R.C.S., F.L.S., Supernumerary Mycologist, was transferred to Coimbatore on April 21st, 1913, to act as Government Mycologist, Madras.

The Entomological Section was in charge of Mr. A. J. Grove, M.Sc., Supernumerary Entomologist, till 29th July 1912, when Mr. H. Maxwell-Lefroy, the Imperial Entomologist, returned from leave. Mr. Lefroy, however, resigned his post on the 30th November 1912 and Mr. Grove was appointed to officiate as Imperial Entomologist. Mr. T. Bainbrigge Fletcher, R.N., F.E.S., Entomologist to the Government of Madras, has been nominated for appointment as Imperial Entomologist. He will take up his duties at Pusa as soon as his successor arrives in Madras.

Mr. F. M. Howlett, B.A., F.E.S., continued in charge of the Pathological Entomological Section throughout the year except for a month and a half in September and October 1912 when he was on privilege leave.

The Bacteriological Section was in charge of Mr. C. M. Hutchinson, B.A., throughout the year excepting three weeks in September-October 1912, when he was on privilege leave.

Mr. J. Hugh Walton, B.A., B.Sc., joined the staff as Supernumerary Agricultural Bacteriologist on 25th October 1912.

The Agricultural Section continued in charge of Mr. S. Milligan, M.A., B.Sc., throughout the year with the exception of one month in September 1912, when he was on privilege leave.

None of the Supernumerary Agriculturists worked at Pusa; Mr. G. D. Mehta, L.Ag., B.A., N.D.A., N.D.D., was under training in the Central Provinces; Mr. N. S. McGowan, Dip. in Agric. (Cantab.), continued to act as Deputy Director of Agriculture, Bihar and Orissa; and Mr. T. Gilbert, B.A., Dip. in Agric. (Cantab.), has been working under the Bombay Government.

II.—Work of the Institute.

Scientific Work.—An account of the scientific work of the Institute during the year is given in the reports of the several sections.

Training.—The training of students on the lines laid down in the Prospectus was continued, and short courses were also given in Cattle management, Sericulture and Lac culture.

During the year under report, five students were under training in Agricultural Chemistry. Of these one Government stipendiary deputed by the Bengal Department of Agriculture, and one private student from the Central Provinces resigned. One Government student deputed by the Agricultural Department of Bihar and Orissa was

recalled for duty at the Agricultural College, Sabour, before the completion of his course. The remaining two students (a Government stipendiary from the Travancore State and a private student from Madras) continued their course.

A private student from Madras was admitted to the post-graduate course in Economic Botany on 1st October 1912.

The Entomological and Mycological collector deputed by the Agricultural Department of Bihar and Orissa, and referred to in last year's report, was under training in the Mycological Section until August 17th, 1912, when his course was terminated as he was found unfit for further training.

In the Entomological Section, the student deputed by the Department of Agriculture, Travancore, continued his training, and a student deputed by the Assam Department of Agriculture was admitted on November 1st, 1912, to the post-graduate course. An Agricultural Assistant of the School of Agriculture, Giza, deputed by the Egyptian Government, was given three months' training in practical Entomology.

Besides the regular students mentioned above, the following visitors to the Institute worked in the Entomological Laboratory during the year :—

Dr. L. H. Gough, Entomologist to the Department of Agriculture, Egypt, in September 1912, in connection with the boll-worm parasite.

Mr. A. Alfieri of the Khedivial Agricultural Society of Cairo from July to September 1912, in connection with the boll-worm parasite.

Lala Bishember Das, Assistant Professor of Biology, Government College, Lahore, from October to December 1912.

Lala Madan Mohan Lal, Assistant Professor of Entomology, Agricultural College, Lyallpur, for three weeks during October 1912.

The Entomological Assistant of Baroda came to Pusa in April 1913 to discuss the programme of his work for the ensuing year. The Weaving Expert to the Government of Bengal and the Principal of the Weaving School, Benares, inspected the work of the Silk-House at Pusa.

A course of instruction in identification, breeding and general observation of *Stegomyia* was given by the Imperial Pathological Entomologist in July 1912 to Medical Officers engaged in the " Stegomyia Survey."

A probationary research Assistant under the Agricultural Chemist to the Punjab Government was deputed to this Institute to undergo training for one year in Bacteriological methods. He joined the Bacteriological Section on 13th August 1912.

As the existence of facilities at Pusa for post-graduate study becomes known, there is a steadily increasing number of enquiries concerning them, and towards the end of the year under report several applications for admission were received from private students. Every encouragement is given to such students, and it is hoped that the thorough training they can obtain at Pusa will enable them, on leaving, to secure remunerative employment in the special lines they have taken.

During the year under report, 19 students attended the short courses—three in " Cattle management," nine in " Sericulture " and seven in " Lac cultivation." Most of these students came from the Native States of Travancore, Bhopal, Karauli and Mysore.

III.—Publications.

Publications.—The issue of the Journal, Memoirs and Bulletins was continued. The demand for the Journal and Bulletins, which deal in a popular way with matters of practical interest, is steadily increasing. The Department published, during the year, 19 Memoirs and 5 Bulletins; against 14 Memoirs and 4 Bulletins in the previous year. The Provincial Departments continue to

supply an increasing number of contributions for these publications.

The first bacteriological memoir was published during the year, the section having been comparatively recently organised.

A Veterinary Series was added to the scientific memoirs of this Department during the year under review, and three issues were published during the year. Two more are in the press. This series of memoirs is open to receive papers from all members of the Civil Veterinary Department and other workers in Veterinary Science in India. It has also been decided to publish as Bulletins of this Institute, veterinary papers which are unsuited for publication in the Agricultural Journal of India or in the veterinary series of scientific memoirs. One such was published as Bulletin No. 32.

The Government of India have sanctioned a permanent annual grant of Rs. 29,000 for the agricultural and veterinary publications issued by the Imperial Department of Agriculture. As a result of the expansion of departments and the greater experience on the part of the staff, the number of publications continues to increase and it has been necessary to exercise the greatest economy in connection with publications.

IV.—General Administration.

Buildings and Works.—During the year under report the Government of India sanctioned the construction of two additional bungalows for European officers, the extension of the library and the extension of the Director's office building. A proposal to install electric lights and fans in the European bungalows and the Guest House at Pusa, and to work the farm machinery electrically, is under consideration.

Library.—The third edition of the catalogue of the library is under preparation. The library is rapidly becoming overcrowded, and during the year over a thousand volumes have been added, besides several foreign bulletins,

memoirs, reports, etc. An ever-increasing number of agricultural publications is received in exchange from all parts of the world.

Pusa Middle English School.—In November 1912, a Government Middle English School was established within the Pusa Estate for the education of the children of the subordinate staff of the Institute. The school is also open to the public in the surrounding villages. Plans and estimates for the school building and for quarters for teachers, are under the consideration of the Government of Bihar and Orissa, and the school is at present located in temporary quarters. As the Middle English School does not meet the requirements of the staff at Pusa, proposals have been submitted to the Government of India for raising the present school to the status of a High School and also for the establishment of a Girls' School at Pusa.

General Health of the Station.—The general health of the station during the year under report was, on the whole, very good. Medical relief was afforded to 8,538 new cases of which 8,333 were treated in the out-patients' department of the hospital and 205 were admitted as indoor patients. One hundred and eighty-three cases amongst European officers and their families were attended to. The daily average number of patients treated was 52·73 outdoor and 9·64 indoor.

Three deaths occurred in hospital, one from Debility (old age), one from Empyema and one from Malarial Cachexia.

An epidemic of cholera, which broke out in the villages in the immediate vicinity of Pusa during the months of April, May, and June, threatened to be a source of great danger. The disease entered the Estate during the earlier part of the outbreak and one man was attacked, but recovered. Immediate and successful measures were adopted, including the thorough cleansing and disinfection of all the wells on the Estate, to prevent the spread of the disease.

One hundred and forty-one surgical operations were performed, of which thirty were major, and one hundred and eleven minor.

The number of Estate cases treated for malarial fever was considerably less than during the previous year; this was most probably due to the fact that the inhabitants were more willing than heretofore to take quinine prophylactically towards the close of the monsoon.

Eleven primary vaccinations and five re-vaccinations were performed during the early part of the year.

Lieutenant-Colonel F. J. Drury, I.M.S., Inspector-General of Civil Hospitals, Bihar and Orissa, visited Pusa on the 7th December 1912 and inspected the Hospital and the medical arrangements. He has recommended the addition of a Female Ward to the Hospital, and proposals for its construction are under consideration. The Government of India have recently sanctioned the appointment of a midwife to be attached to the Hospital.

V.—Accounts.

The total expenditure during the financial year 1912-13 was Rs. 4,00,077 as under :—

	Rs.
Office of the Agricultural Adviser to the Government of India and Director of the Institute	1,43,509
Chemical Section	34,828
Mycological Section	39,650
Entomological Section	36,914
Pathological Entomological Section	26,641
Botanical Section	36,099
Bacteriological Section	23,783
Agricultural Section	58,653
Total	4,00,077

The above amount of Rs. 4,00,077 included expenditure under the special grant of Rs. 10,000 placed at the disposal of the Agricultural Adviser for special Agricultural Experiments.

The principal items of expenditure under this special grant were as under :—

	Rs.
(1) Experimental cotton cultivation conducted by the Imperial Cotton Specialist	2,000
(2) Contribution towards the pay of the Flax Expert engaged by the Bihar Planters' Association for 1912-13 . . .	2,750
(3) Purchase of special agricultural implements and machinery	2,210
(4) Saltpetre experiments carried on by the Imperial Agricultural Chemist . .	380
(5) Poultry Experiments at Pusa . . .	1,210

The budget of the Agricultural Adviser also includes a grant of Rs. 1,10,000 for meeting the expenditure for three years from 1911-12 in connection with the engagement of Mr. W. Hulme as Sugar Engineer in the United Provinces for the development of the Indian Sugar Industry; and a grant of Rs. 15,000 for payment to the Indian Tea Association as a grant-in-aid.

In March last, the Government of India provisionally allotted, out of the surplus of Imperial Revenue, a sum of Rs. 60,000 for improvements connected with the Pusa Institute. This special grant will be mainly utilised for the purchase of steam cultivating machinery and labour-saving appliances, the extension of the library, the development of the fruit work at Quetta, the testing of milling and baking qualities of wheats, bacteriological investigations in connection with rice cultivation, the demonstration of improved methods of saltpetre refining, the construction of a potculture-house for mycological investigations and other minor improvements.

The gross receipts during the year by sale of farm produce, milk, and other miscellaneous articles, amounted to Rs. 14,663 as against Rs. 9,455 of the preceding year.

VI.—Visitors.

The Hon'ble Sir Charles Stuart Bayley, K.C.S.I., I.S.O., Lieutenant-Governor of Bihar and Orissa, visited

the Institute on the 31st January 1913. His Honour took this opportunity to invest Mr. Bernard Coventry with the insignia of the "C.I.E." and to present the *Kaisar-i-Hind* Gold Medal for public service in India, to Mrs. Howard, M.A., Personal Assistant to the Imperial Economic Botanist. His Honour was accompanied by Lady Bayley and the Private Secretary, and the party included the Hon'ble Mr. E. V. Levinge, C.S.I., Member of the Board of Revenue; the Hon'ble Mr. H. LeMesurier, C.S.I., C.I.E., Chief Secretary to the Government of Bihar and Orissa; the Hon'ble Mr. F. N. Fischer, I.C.S., Commissioner, Tirhut Division; Mr. W. B. Heycock, I.C.S., Director of Agriculture, Bihar and Orissa; and Mr. A. H. Vernede, I.C.S., Collector of Darbhanga.

During the year under report the Hon'ble Sir Harcourt Butler, K.C.S.I., Member-in-Charge of the Education Department of the Government of India; Sir Krishna Gobinda Gupta, K.C.S.I., Member of the Secretary of State's Council; Mr. H. N. Ridley, C.M.G., M.A., F.R.S., F.L.S., F.R.H.S., retired Director of Gardens, Singapore, and many others, also visited the Institute.

REPORT OF THE IMPERIAL AGRICULTURIST

(S. Milligan, M.A., B.Sc.)

I.—Administration and Tours.

Charge.—I held charge of the section throughout the year with the exception of one month spent on privilege leave in September.

Supernumerary Establishment.—None of the Supernumerary Establishment have worked under me during the year.

Mr. G. D. Mehta, Supernumerary Agriculturist, who was on deputation under the Government of Bombay, is now under training in the Central Provinces.

Mr. N. S. McGowan, Supernumerary Agriculturist, is working as Deputy Director of Agriculture, Bihar and Orissa, from 23rd February 1912.

Mr. T. Gilbert, Supernumerary Agriculturist, is at present working under the Bombay Government.

Staff.—Mr. Judah Hyam continued in charge of the breeding herds. He was on privilege leave from 2nd January 1913 to 4th February 1913, during which period Mr. L. S. Joseph, Veterinary Assistant, acted for him.

Mr. Mohamed Ikramuddin held the post of First Farm Overseer throughout the year. He has performed his many and varied duties satisfactorily.

Mr. Mohamed Ziauddin Hyder worked as Second Farm Overseer until 15th May 1913, when he left this department on transfer to the United Provinces Agricultural Department.

Babu Kshiti Bhusan Mukerji, Senior Fieldman, left Pusa on 11th February 1913 on transfer to the Bihar and Orissa Agricultural Department.

Babu Brajraj Mukerji was promoted to the post of Senior Fieldman from 11th February 1913.

Tours.—During the year I made several short tours in Bihar and conducted the final examinations in Agriculture at Coimbatore and Lyallpur in March and April.

Training.—Three students were instructed in cattle breeding.

II.—Farm Cultivation.

Character of the Season.—The rainfall during the year amounted to 41·26″ (*i.e.*, from 1st May 1912 to 30th April 1913) as against 53·49″ last year.

Monsoon rainfall began early and continued normal up to the second week in July. The bad effects of a prolonged break during the latter half of that month were mitigated by fairly well distributed rains in August. The September and October rainfall was, however, far short of normal. Late rains in November and February, however, improved the rabi crops considerably. The season was thus unsuitable for rice, sugarcane, maize and wheat, but fairly good for such crops as *sarson*, oats, etc.

Cropping.—The present double cropping system appears to require the application of organic manures at more frequent intervals to ensure maximum yields. During the present year owing to the scarcity of rainfall in September and October no increase was obtained in the wheat crop succeeding a green manuring with sunn hemp. The manure evidently became available at too late a date to affect the grain outturn.

The following crops were grown:—Sugarcane, maize, wheat, *sarson*, *guar*, turnips, oats, gram, linseed, lucerne, paddy, *mung*, *joar*, *khesari*, oats and peas, *arhar*, Florida velvet beans, sweet potatoes, *kudzu* (a Japanese fodder), guinea grass, *bajra*, cowpeas, castor, indigo and jute.

Experimental Cultivation and Implements.—Suitable methods of sowing and inter-cultivating sugarcane and maize have been worked out. The most economical spacings for these crops are under investigation. Implements suitable for inter-cultivation are under trial. A year's experience of the heavier low-lying area has demonstrated the

great superiority of revolving harrows and sectional rollers over drag-harrows and levelling beams for dealing with this class of land.

The permanent manurial experiments have been continued.

The green manuring experiments in collaboration with the Imperial Agricultural Bacteriologist have been altered in conformity with last year's experience.

The use of crude khari salt for rice.—This salt was applied as in last year's experiments in September, but on account of the dryness of the soil had little effect.

Artificial sprouting of sugarcane.—This practice proved useful against the attacks of termites.

Fodder.—The following fodder crops have been under observation :—Guinea grass, lucerne, *kudzu*.

III.—Live-stock and Poultry.

Breeding Herd.—During the year 13 cows and 22 young cattle have been sold.

Present numbers are :—

	Cows.	Bulls.	Young stock.
	89	3	137
as against	74	5	118

at the same date last year.

During the last two years an attempt has been made to train the young cows to give milk without the presence of their calves. The result has been very disappointing and the practice has had to be abandoned.

The average milk production of the herd has improved considerably owing to a more rigid selection of the cows. This year's additions have been all tested previous to purchase with regard to their milking qualities.

Tuberculin Test.—The milk cows were for the first time subjected to the Tuberculin Test by the local Veterinary Department. None reacted.

Sheep.—The lambing period has been regularized and limited with satisfactory results. Crossing with Dhumba and half-bred Gorakhpore Dhumba rams has been continued. Two Merino rams have been imported for the improvement of the quality of the wool. Some time must elapse before results of any value can be obtained. The first cross between the Gorakhpore and Dhumba breeds, however, results in an improved mutton sheep. Gorakhpore ewes are still used as the female parents in these experiments.

Poultry.—The three breeds, White Wyandotte, Buff Orpington and Chittagong, having proved the hardiest and best generally of the large number of varieties tried at Pusa, it has been decided to maintain these and the Mammoth Bronze Turkeys on certain of the Provincial farms and they are being distributed accordingly; new blood will be supplied from England when necessary. The only breed maintained at Pusa in the immediate future will be the Buff Orpingtons.

IV.—Pastures.

Pastures.—A great improvement has been made in the grazing of both the low-lying and higher pasture areas through topping the grasses before seeding time with hay mowers and occasionally harrowing down the cattle droppings. The effect of rolling, except on newly laid out pastures, is slight.

The economics of laying land down to pasture are being studied. A collection of the more valuable indigenous pasture grasses has been made. These are at present being grown as pure cultures.

V.—Clearing and Levelling.

Clearing and Levelling.—Thirty acres of land in the low-lying brick-field area have been reclaimed. A considerable amount of levelling has been done in the more suitable fields with a view to increasing the experimental area which is at present very inadequate.

VI.—Programme of work for 1913-14.

Permanent Experiments.—These experiments will be continued. In the low-lying area gram will be substituted for *arhar* in the leguminous rotation on account of the liability of the latter crop to suffer from waterlogging in the rains. In the higher area gram will be alternated with *arhar*. To the green manuring series a plot will be added in which superphosphate is applied to the green manure.

A special study of the maintenance of soil fertility under a double and single cropping rotation will be made.

Field experiments on green manuring in collaboration with the Imperial Agricultural Bacteriologist will be continued.

New Crops.—A special area is being prepared for the trial of new crops.

Cultivation.—Special attention will be paid to the improvement of methods of cultivation of the sugarcane crop, including subsoiling and the improvement of local drainage.

New methods of dealing with heavy soils will be tried.

The improvement of the methods of renewing pastures is under trial and will be continued.

Breeding.—(*a*) *Cattle.*—The improvement in the milk yield of the Montgomery herd by selective breeding will be continued.

(*b*) *Sheep.*—The breeding experiments are being continued. The value of the Merino rams as sires for crossing is being tested.

General.—It is expected that the remaining uncultivated arable area will be reclaimed this year.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST

(J. Walter Leather, V.D., Ph.D., F.I.C.)

I.—Administration and Tours.

Charge.—This section was in the charge of myself during the whole year.

Establishment.—Mr. H. E. Annett, Supernumerary Agricultural Chemist, continued to officiate as Agricultural Chemist, Punjab, until November when he proceeded on one year and nineteen days' privilege leave and study leave, and has therefore been absent during the whole year.

Mr. Bhailal Motibhai Amin, third assistant, continued on deputation at the Sirseah Indigo Research Station until April 30th, when this station was closed and he re-joined his appointment in this section.

Mr. A. V. Iyer, fourth assistant, was appointed Assistant Agricultural Chemist, Bihar and Orissa, on 3rd November 1912. Mr. Lele was appointed in his place.

Babu Narendra Nath Mitra, M.Sc., an assistant, was appointed demonstrator in Chemistry at the Thomason Engineering College, Roorkee, on 2nd January 1913.

Babu Nirmal Chandra Bose, M.Sc., who was appointed in a temporary vacancy for three months, was appointed an assistant in the Bacteriological Section.

The vacancies which occurred during the year have been filled up by the appointments of Babus Phani Bhusan Sanyal, M.Sc., and Har Dyal Singh, B.Sc., as junior assistants.

It is naturally eminently satisfactory to find that there is such a constant demand for the services of assistants from this section, and this fact at the same time markedly assists recruitment, but on the other hand it means that of the establishment of eight assistants several are always merely under training and of no use for the general work

of the section, much less for research work. I desire to place on record my appreciation of the good services rendered by all, both the gazetted and non-gazetted officers, each of whom has evinced an exemplary interest in his special duty.

Tours.—The following tours were made by myself :—

1. July 1912. To Assam to advise the Scientific Officer of the Indian Tea Association regarding the fitting of the new laboratories.
2. August and November 1912. To Cawnpore and Orai in order to test a new method of determining soil moisture.
3. November 1912. To Marhowrah Sugar Factory to test a filter press.
4. February and March 1913. To conduct tests of sugarcane at the Parsa Factory.
5. March 1913. To the Muttra District to inspect the land included in the Nuh Jheel Project.
6. April 1913. To Cawnpore to test the effect of explosives on Usar land.
7. April to May 1913. To Peshawar to test sugar-beets.

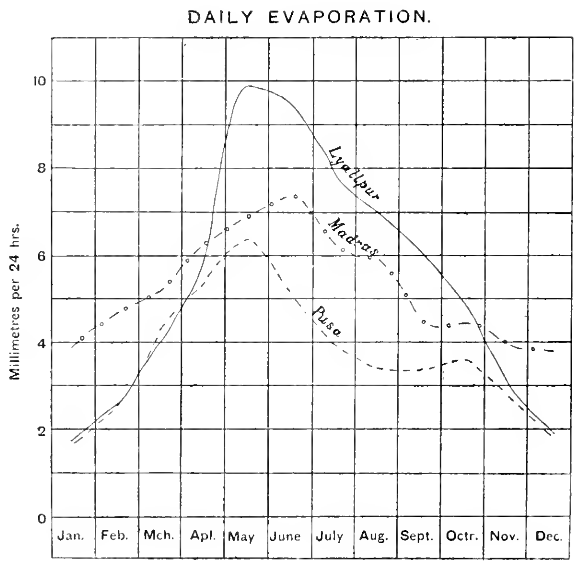
II.—Education.

Training.—Five students have been under instruction during the year. Of these one Government stipendiary and one private student resigned; one Government student was recalled for duty at the Agricultural College, Sabour, at the end of his first year's course, and the remaining two students are continuing their courses.

III.—Meteorology.

In addition to the usual data which are recorded daily on behalf of the Meteorological Department, records of (*a*) evaporation, (*b*) soil temperature, (*c*) drainage, and (*d*) pressure by means of a barograph have been maintained.

The records of *evaporation from a plain water surface*, after being maintained for about three years, were concluded during the past year because it seemed that no useful object would be served by more extended records. The data, together with others on the same subject, have been published as a Memoir. With the aid of these data, and others obtained at Lyallpur by the Irrigation Department, an empirical formula was deduced for the calculation of the evaporation at any place in India with the aid of the usual meteorological data. The accompanying chart illustrates



the quantity of water which becomes dissipated per day during the year at Pusa, Lyallpur and Madras. It rises to a much higher figure at Lyallpur during the hot weather than at Pusa or Madras, whilst during the cold weather the rate at Madras is higher than either of the other stations. The total water evaporated per annum is as follows :—

	cm.	ft.
Lyallpur	196	6·4
Pusa	126	4·1
Madras	193	6·3

These quantities are naturally much greater than what is lost from agricultural land. At Pusa the records show that from fallow soil the annual loss is (approximately) 28″, at Cawnpore 18″. Where crops are growing the quantities of water which are evaporated and transpired are somewhat greater[1] though the difference is not large.

The data regarding *soil temperatures* now extend over two years and they will be written up with a view to publication. They have shown that at Pusa, with a maximum hot weather temperature of, say, 110° F. (43° C.) the following maxima are realised in fallow soil :—

	°F.	°C.
1″ from surface	109	43·0
2″ from surface	106	41·0
3″ from surface	102	39·0
6″ from surface	97	36·0

The air temperature of many parts of India rises considerably above that of Bihar. In the Punjab maximum temperatures of 115° to 120° F. (46°—49° C.) are regularly registered for some weeks during the hot season and there the upper soil will naturally attain a correspondingly higher temperature than has been recorded at Pusa.

It has recently been shown[2] by Russell and Hutchinson that heating a soil to 122° F. (50° C.) occasions material biological changes of a beneficial nature, and that if a soil is heated for a sufficiently long time to 40° C. (104° F.) similar changes may occur.

Such soil temperature records therefore become of some practical importance. At the same time it must not be forgotten that not only is this subject a new one and at present very imperfectly understood, but also that in any case it is only the topmost 3″—4″ which are liable to such temperatures, whilst below this depth these biological changes are presumably either modified or non-existent. Also that the cultivating implements annually cause an

[1] *Memoirs, Department of Agriculture in India*, Chemical Series, Volume II, No. 2, pages 12—14.

[2] *Journal of Agricultural Science*, V, pages 152—220.

intermingling of these various layers or strata; so that conclusions regarding the biological effects of India's hot weather on the soil must be made very guardedly and not in the offhand manner that has been in some instances the case. It may be assumed as certain that "hot weather weathering," whilst valuable in some cases, will be undesirable in others.

IV.—Soil Problems.

The records of *drainage* which are obtained by means of the special gauges fully described in the Memoirs[1] have been continued. The nature of the crops grown was changed two years ago. On one gauge sann hemp, *Crotalaria juncea*, is grown during the monsoon and removed in September as near the end of the rains as may be without, however, leaving the land deficient in moisture, after which wheat is sown; on another gauge sann hemp is grown during the monsoon and allowed to ripen thoroughly when it is removed, and this soil then lies fallow. It is too early to draw any conclusions, but so far the wheat crop has not suffered from want of moisture, whilst the sann hemp on the second of these two gauges which is not alternated with another crop, already shows some signs of the deterioration which is so common where a leguminous crop is grown continuously on the same land. The object of the present system of cropping is to ascertain whether the marked deficiency of nitrate in the drainage water, which was noticed when the crops were wheat and maize, would be again experienced. (*Vide* Memoir, Volume II, No. 2, pages 31 *et seq.*)

Soil Moisture.—The investigations regarding the amounts of water present in Indian soils and the requirements of crops which have been carried out for some years by this section, showed the great necessity that exists for a rapid method of determining the amount of water in soils. The usual one of drying a weighed portion of soil in an oven is comparatively very time-absorbing, and

[1] *Memoirs, Department of Agriculture in India*, Chemical Series, Volume I, No. 5, and Volume II, No. 2.

consequently some attention has been paid to this question during the past three years. Hitherto, however, the object has not been successfully attained. Two new methods were tried during the past year, but neither was sufficiently accurate.

Water Requirements of Crops.—During the last monsoon season a series of pot-cultures were made in order to test the effect of different proportions of water in various soils on certain crops, namely, maize and cotton. It is of course well recognised that a too low proportion of moisture in a soil will prevent a full development of a plant, but the information available as to what is a too low proportion or a too high one for any particular soil and crop is extremely scanty, and practically non-existent for India. Moreover, as was to be expected, the effect of a low proportion in a particular soil varied with the crop. Whilst some interesting information was obtained by the pot-cultures, it seemed very doubtful whether this method is suitable for the proper solution of the enquiry; the work will probably have to be undertaken in the field.

Usar Soil.—In January I was requested by the Chief Engineer, Irrigation Branch, Public Works Department, United Provinces, to examine some land in the Muttra District which it has been proposed to bring under irrigation, and to report as to the probability of it becoming saline.

The tract is a section of *khadir* land on the Jumna, and the proposal includes the regulated admission of river water annually for irrigation purposes and its subsequent removal by drainage. Although the wells in the neighbourhood are frequently saline, the soil of this tract is generally very free from any contamination. Tests made on specimens which appeared likely to contain usar salts, showed that these consist of sulphate and chloride only, whilst the more harmful carbonate is absent. Moreover, the soil is very open and easily drained. There was no indication that if the project were carried through harmful results would follow.

The Use of Explosives in Agriculture.—For some short time past the use of dynamite or other similar explosive for the breaking up of "hard pan" or the removal of tree stumps, has been recommended in the press. It is a subject which naturally lends itself to "copy," but should be approached with some little consideration. Experiments have been made at Cawnpore and at Pusa by myself in collaboration with the Chief Chemical Examiner, Ordnance Department, and the Deputy Director of Agriculture, Central Circle, United Provinces, and a separate report will be made. In any case these experiments will have to be considered preliminary, but it may here be suitably remarked that these explosives are comparatively expensive in India at present; also that, whilst it is possible to ascertain immediately to a limited extent what the nature of the effect of the explosive has been in any particular case, its agricultural value can only be subsequently ascertained by the growth of trees or crops on the land. Hence in any case it will only be possible to appraise correctly the financial aspect after the lapse of several years.

V.—Saltpetre.

After the failure which was referred to in last year's report, a test was made on a small scale with a filter-press. This press, which was borrowed locally, was not only small, but was imperfect in several of its parts. It was, however, sufficiently well repaired to test the probability of such a press being useful, and having shown considerable promise, a large sized one was ordered from Europe. This is expected to arrive shortly, and further experiments will then be made. In the meantime the salt "systems" which are involved, are being worked out by Babu Jatindra Nath Mukerjee, the assistant who is in charge of this work.

VI.—Sugar.

Date Palm Sugar.—Owing to Mr. Annett's absence no further work on this subject has been done, but the infor-

mation which he collected during the two preceding seasons was published during the current year as a Memoir.[1]

Cane Sugar.—As mentioned in my last report, tests had been made over two seasons of the experimental error which is involved when a "sample" of cane is taken from a field or plot of this crop. Dr. Walker, the Director General of Observatories, very kindly examined the results which I had obtained, and acting on suggestions which he made to me, a third series of tests were carried out during the past season. These resulted in more definite information and showed clearly what the probable error is when the sample is taken by certain methods. The matter has been put together for publication as a Memoir and is now in the press.

Sugar Beet.—Reference was made in my last annual report to the fact that some very good specimens of sugar beet had been grown at Peshawar by Mr. Robertson Brown, the Superintendent of Farms. This year I took apparatus to Peshawar and tested the fresh roots, which is naturally more satisfactory than testing them at Pusa after a long railway journey. A considerable number of individual roots were tested, as also average samples of 100 roots each from each field. A good deal of variation in size and quality was met with among individual roots, the percentage of sucrose varying from 9·0 to 20·0. The average samples tested 15·8 per cent. and 15·3 per cent. sucrose respectively, thus showing conclusively that this crop can be successfully cultivated in that part of India. The above percentage of sugar is materially better than some of the initial crops which were raised in San Francisco when the industry was first started there. I understand that the experiments will be extended considerably during the present year. There can be no doubt that this crop possesses great potentialities.

VII.—Milk.

Reference was made in last year's report to a series of tests, which was being made in conjunction with my col-

[1] *Memoirs, Department of Agriculture in India,* Chemical Series, Volume II, No. 6.

league Mr. Dobbs, of the quantity and composition of the milk of the Montgomery herd that is maintained here. The work was continued in the autumn and it is proposed to publish the records shortly.

VIII.—Programme of work for 1913-14.

Major subjects :—

1. Investigations of the availability of plant food in soils will be continued.

2. Experiments on possible improvements in the refining of saltpetre will be continued.

3. The variations of certain physical and chemical properties of individual seeds of the same plant are being examined.

4. The records of the amount and nature of drainage water from fallow land and from land under crops are maintained.

Minor subjects :—

5. An attempt is being made to ascertain the nature of the hydration of clay in soil.

6. The permeability of soils to water is being studied.

7. The relation of moisture in cereal grains to weevil attacks and the manner of absorption of certain insecticides is being examined in collaboration with the Imperial Entomologist.

Education.—This requires no special comment and will be conducted according to the lines laid down.

IX.—Publications.

The following have been published :—

1. The Date Sugar Industry in Bengal. H. E. Annett. *Mem. Dept. of Agri. in India*, Chem. Ser., Vol. II, No. 6.
2. Evaporation from a Plain Water Surface. J. Walter Leather. *Mem. Dept. of Agri. in India*, Chem. Ser., Vol. III, No. 1.

3. The Experimental Error in Sampling Sugarcane. J. Walter Leather. *Mem. Dept. of Agri. in India*, Chem. Ser., Vol. III, No. 4 (*in the press*).

REPORT OF THE IMPERIAL ECONOMIC BOTANIST

(A. Howard, M.A., A.R.C.S., F.L.S.)

I.—Teaching, Training and Staff.

Charge.—I held charge of the section at Pusa during the year under review till April 28th, when I took six months' combined leave. The Second Assistant, Maulvi Abdur Rahman Khan, was placed in charge of the current work of the section at Pusa, and the Third Assistant, Munshi Ijaz Husain, was placed in charge at Quetta during my absence.

Students.—One advanced student from the Madras Agricultural College worked in the section from October 1st, 1912, to the end of April 1913. He has, I understand, since obtained an appointment at Coimbatore in the Provincial Agricultural Department.

Staff.—The work of the staff continues to be satisfactory. The Second Assistant has done excellent work at Pusa while the Third Assistant at Quetta has done well. The two fieldmen, Sarup Singh and Ram Pershad, and the clerk, Babu Ram Nechhawar Lal, worked well during the year.

II.—Wheat Investigations.

The wheat investigations continue to extend and during the past year results of considerable value have been obtained.

Distribution of Pusa Wheats in India.

The growth of Pusa wheats in the various wheat-growing tracts of India has now emerged from the experimental stage and the distribution of seed is in progress on a large scale in Bihar, the United Provinces, Central Provinces and, to a limited extent, in the *barani* tracts of the Punjab.

Extensive seed farms for the growth of these wheats are now in working order and high grade seed, true to type, is being supplied in large quantities to the public.

The preliminary work relating to the improvement of the Indian wheat crop need only be referred to very briefly. One of the first practical results of the wheat investigations at Pusa was the demonstration of the fact that varieties with milling and baking qualities, similar to those of the best wheats on the English market, could be grown in Bihar under *barani* conditions. By the application of modern methods of selection and hybridization these high grain qualities were successfully combined with high yielding power, rust-resistance and strong straw so that wheats were found which gave, on land in fair cultivation, upwards of 2,500 lbs. of grain to the acre without irrigation. The milling and baking tests connected with this work were carried out in England by Mr. A. E. Humphries, a past President of the Incorporated Society of British and Irish Millers and a well-known authority on these questions. Mr. Humphries reported that the Pusa wheats were a great advance on those exported from India and behaved in the mill and bakehouse like Manitoba spring wheats, which are in greatest demand for bread making in England and which command the highest prices on the Home markets. At the same time enquiries were made in India itself as to the suitability of the new wheats as food for the people. In all cases both cultivators, landholders and the educated community preferred for their own food the Pusa wheats to those ordinarily grown in India.

The next step was to determine whether or not grain quality would be affected by growing these wheats in different localities in India and particularly under canal irrigation. In collaboration with Mr. Leake and with the assistance of a large number of officers of the Agricultural Department this work has been undertaken and the same wheat has been grown for several years at a large number of stations in the various wheat tracts and the samples have been tested by Mr. Humphries in England. The fact

has been demonstrated that wheats of first-rate quality can be grown under canal irrigation on the alluvium and also on the black cotton soils of Peninsular India.

During the past year the earlier results have received important confirmation. Pusa wheat grown in the Indus valley and on the black cotton soils has given better results in the mill and bakehouse than the same variety grown at Pusa. The general results are summed up in Mr. Humphries' last report as follows :—

" It has again been demonstrated that wheats of the highest class can be grown in India on several kinds of soil, and on land which has been irrigated. It has been shown that the high excellence of quality possessed by wheats grown at Pusa in previous seasons was not due to environment or agricultural practice, for the same varieties of wheat have yielded still better results elsewhere. It is interesting to note that this high excellence of quality was found existing in wheats indigenous to India, and that in the Pusa Nursery varieties, the progeny appear to possess intact the great strength of the strong parents. I have no doubt that any or all of the wheats tested will realize, some at once, some later, relatively higher prices on our markets than the existing Indian wheats of commerce. If these new varieties yield no more grain and straw per acre than those ordinarily grown, their extended distribution as seed is desirable; if, in addition, the new varieties will yield greater quantities of grain and straw than those ordinarily grown, the position of the Indian grower will be greatly improved, and the propagation of the new kinds should be pressed forward."

The most important feature of this last series of tests was the superiority, in the mill and bakehouse, of the samples of Pusa 12 from three stations in the Indus valley (Lyallpur, Mirpurkhas and Gurdaspur) over those grown in the Ganges valley. The significance of these results lies in the fact that high grain quality can be obtained in all the great wheat-growing tracts of India including the Punjab

and the black cotton soils of Peninsular India, both under dry and irrigated conditions. This is an important matter and one which must be considered in all schemes of wheat improvement. There is no longer any reason why (now that it has been shown that yield and quality can be combined in the same wheat) the distribution of poor quality wheats should be continued.

The attention of the wheat trade at Home has been drawn to the work in progress on the improvement of Indian wheat. A meeting was arranged this summer by Mr. Humphries at Weybridge with Mr. Petrie, the London Manager of Messrs. Ralli Brothers, when samples of Pusa 12, grown at the various stations in the Indo-Gangetic plain and on the black cotton soils of Peninsular India, were exhibited. The loaves obtained from this wheat were also shown side by side with those produced from the grade known as Choice White Karachi and No. 2 Northern (Manitoba). The loaves from Pusa 12 were almost identical with those from No. 2 Northern and were a great improvement on those obtained from Choice White Karachi flour. The opportunity was taken of obtaining Mr. Petrie's advice as to the best means of disposing of these wheats on the Home markets and of establishing the reputation of a grade of Indian wheat with superior quality. In addition, a sample of Pusa 4, grown on the Hathowrie Estate in Bihar in 1912-13, was exhibited at Mark Lane at a recent meeting of the Council of the Incorporated Association of British and Irish Millers where the wheat attracted a considerable amount of attention.

The present position of the cultivation of the Pusa wheats in the various wheat-growing tracts of India must now be considered. The work is being carried out by many officers of the Agricultural Department and the details given below have been obtained, partly from the publications and reports issued in the various provinces and partly by correspondence.

United Provinces.—The first experiments with Pusa wheats in these Provinces were made in the Botanical area

at Cawnpore by Mr. Leake, who showed for several years that fine samples could be grown under canal irrigation using far less water for the purpose than is ordinarily given to wheat. During the progress of this work at Cawnpore, the Allahabad Exhibition took place and at the Agricultural Conference which was held in connection with the Exhibition the Pusa wheats were shown. As a result, the Manager of the Court of Wards' Estates in the District of Kheri, Mr. Hoskins, became interested in the matter and some of the new wheats were grown successfully by his tenants in the season 1911-12. The results obtained from these various experiments led to a demand for seed. As the land available for wheat in the Botanical area at Cawnpore was not sufficient for seed-growing purposes, it was decided by Mr. Leake to utilize about 100 acres of the new farm at Kalai, near Aligarh, for the purpose of growing seed for distribution. The first crop was grown in the season 1912-13 and the yields of the various wheats over large areas are given below. Mr. Leake states that there was a failure of the canal and consequently some damage by white-ants, and that these facts must be considered in judging the outturns.

Yield of Pusa wheats at Kalai near Aligarh, 1912-13.

Name.	Yield in lbs. per acre.
Pusa 12	2,214
Pusa IX A 2	2,050
Pusa 101	2,010
Pusa 4	1,928
Pusa 110	1,846
Pusa IX E 9	1,702
Pusa 8	1,640

Trials were also carried out at the farms at Partabgarh and Benares where the following returns were obtained by Mr. Sharma, the Assistant Director of Agriculture :—

Yield of Pusa wheats at Partabgarh and Benares, 1912-13.

Name.	Yield in lbs. per acre.	
Pusa 12	2,020	Partabgarh.
Pusa 8	1,960	
Pusa 106	1,928	
Pusa 12	2,040	Benares.
Pusa 106	1,856	
Pusa 8	1,760	

The results obtained on the various Court of Wards' Estates were also successful, particularly on the Kheri estates. The season was not favourable to wheat, due to a prolonged drought and scarcity of irrigation water, followed by high winds and storms in February and March. Both Pusa 8 and Pusa 12 did well with the small amount of water the wells could supply, and being strong-strawed wheats stood up while the surrounding crops were laid by the storms.

The distribution of seed in this Province is being taken up energetically by the Agricultural Department. In the Central Circle, Mr. Burt, the Deputy Director, has issued seed for about 1,800 acres, largely to Co-operative Societies and Court of Wards' Estates. A large demand for seed has also arisen in the Eastern Circle as well as in the submontane tracts and a good deal of seed has been distributed in these areas. More, however, could have been distributed had seed been available, but in spite of a considerable amount being supplied by the seed farm at Dholi, near Pusa, the supply was not equal to the demand and the later indents could not be met. A large amount of seed, sufficient for all demands, should, however, be available in the Province next harvest.

Punjab.—During the past *rabi* season an extended trial of one of the Pusa wheats (No. 12) has been carried out by Mr. Southern, the Deputy Director of Agriculture, at the

Gurdaspur Experiment Station. The object of the trial was to compare the behaviour of this white wheat with high grain quality, with Punjab Type 13, a low grade red wheat which was found to be the best yielder of the local kinds. The trials were in duplicate on plots from two to three acres in area and the yields obtained are given in the following table :—

Trial of Pusa 12 and Punjab 13 at Gurdaspur, 1912-13.

Name.	Yield in lbs. per acre
Pusa 12	1,570
Punjab 13	1,161
Pusa 12	1,096
Punjab 13 . . .	1,084

The season was an unfavourable one for wheat. The monsoon ceased in August and no more rain fell before sowing time. After a single day's rain in November, there was a long drought, the Christmas rain failed and the crops were drying up when the storms of February and March improved matters. Hot winds in April, however, ripened off the crop too rapidly and the local variety was poor and shrivelled. Pusa 12, however, gave a very good uniform sample in spite of the unfavourable conditions and a good yield. This is the second time Pusa 12 has done well at Gurdaspur. Seed of this wheat is now being sold to zemindars in the *barani* tracts and it will be interesting to know their experience with this variety.

Pusa 12 has also been grown under canal irrigation by the tenants of the Lyallpur farm who obtained 1,744 lbs. of grain to the acre. The grain is of superior quality and it is probable that this wheat will do well when tried by the cultivators of the Chenab Colony.

Bihar.—The main lines of progress in Bihar during the past year relate to the organisation of seed farms and the supply to the public of well-grown seed, true to type, at a reasonable price.

In connection with the Bihar Planters' Association an arrangement has been made with Mr. Edward Danby to grow a large area of Pusa wheats on the Dholi and Bowarrah estates near Pusa so that a large amount of good seed will be available. This arrangement has been carried out successfully and about 600 acres of wheat were grown in the *rabi* season of 1912-13. Care was taken to rogue the plots, to keep the various kinds separate and to sell for seed only dressed grain of a high grade. The price charged was one rupee per maund above local bazaar rates and the whole seed supply was sold off at once immediately after harvest. Orders for upwards of 1,000 maunds could not be filled. These arrangements are being continued and during the present wheat season about 700 acres have been put down for seed wheat on these estates. The advantages of this method of seed supply are obvious. The expansion of the work is ensured at practically no cost to Government and the estates where the crop is grown to perfection for seed serve as useful demonstration areas to all interested in wheat growing. Further, the profits obtained by the estates should attract the attention of cultivators and zemindars to the advantages, to all concerned, which follow from a supply of good seed.

The returns obtained on this seed farm over large areas are given in the table below. The season was not favourable to wheat. Damage was done by abnormal heat after sowing time and also by a series of storms in February and March which laid the neighbouring crops. Most of the Pusa wheats, however, having good straw, stood well and in spite of the season gave good yields. Great advantage was obtained on this and other estates in Bihar by harrowing the young crops by means of lever harrows.

Yield of Pusa wheats at Dholi and Bowarrah, 1912-13.

Name.	Average yield in lbs. per acre.
Pusa 100	2,050
Pusa 4	1,846
Pusa 8	1,886
Pusa 12	1,640
Pusa 6	1,635

In addition to the seed farms near Pusa under the immediate control of the Imperial Economic Botanist, the distribution of these wheats has been taken up by the Bihar Agricultural Department and seed has been grown at Sabour, Dumraon and Bankipore. Seed for about 200 acres has been distributed by Mr. McGowan in the Bhagalpur Division while the successful trials of these wheats in the Patna Division will be continued. The yields obtained on the light lands of the Sabour farm are given below.

Yield of Pusa wheats at Sabour, 1912-13.

Name.	Yield in lbs. per acre.
Pusa 7	1,809
Pusa 12	1,664
Pusa 8	1,512
Pusa 106	1,087

Many of the indigo estates in Bihar are now taking up wheat growing and there is a considerable amount of local seed distribution in progress. It is impossible to obtain returns of these operations and to say what is the total area under wheat.

During the year two new Pusa wheats have been tried on estates in Bihar, namely, Nos. 4 and 6. The former is an early maturing wheat with strong straw which is very suitable for sowing with Java indigo. This wheat did well in 1912-13 and returns from 1,558 to 1,912 lbs. of seed to the acre were obtained on the various estates where it was grown. At Belsund factory Pusa 6 gave 1,640 lbs. of seed

to the acre which Mr. Reid considered very good for the year.

Central Provinces.—The results obtained in the Central Provinces at the Raipur and Tharsa farms by Mr. Clouston during the past year amply confirm the earlier successful trials of these wheats on the black soils which are referred to in detail in the annual report for 1911-12. A somewhat extraordinary result was obtained at Tharsa with Pusa No. 7 where the yield was 1,240 lbs. to the acre. As the outturn of the local kinds seldom exceeds 600 lbs. to the acre a yield of 1,240 lbs. to the acre is quite exceptional. The actual results of the growth of these wheats by the cultivators in the Eastern Circle have not yet been received as Mr. Clouston is on leave, but it is understood that they have been successful.

So far only one wheat, Pusa 4, has been tried at Hoshangabad. The results were satisfactory. This kind is also being tried at Jubbulpore by Mr. Evans who has this year asked for a further supply of seed.

The results of the recent milling and baking tests of Pusa wheats grown at Raipur, Tharsa and Hoshangabad are of considerable importance. The behaviour of these samples was somewhat better than that of the same wheats grown at Pusa and other stations in the Gangetic plain. As high grain quality is now shown to be possible on the black cotton soils of the Peninsula, a great improvement in the wheats grown can easily be accomplished.

Wheat Breeding.

Practically all the first set of improved wheats obtained at Pusa by selection and hybridization have been tried on the large scale in various tracts in India and the most suitable of these are now being grown for distribution on various seed farms. These wheats will be grown on, at Pusa, in pure culture, so that when necessary the seed farms can be re-stocked with a fresh supply of seed of any particular variety.

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During the testing of these early selections and hybrids, considerable progress has been made in the work relating to a new set of crosses which promise to give still better results than the earlier ones. The object in view in this work has been to improve the best of the Pusa wheats in standing power, rust resistance and also in general hardiness. For this purpose crosses between Indian wheats, with good grain quality, and various English and American varieties were made in England in 1910 and two series of these hybrids are now in the fourth generation. This is by far the most promising material yet obtained at Pusa and it is more than probable that the strong straw, rust resistance and general vigour and hardiness of the English parent has been, as it were, introduced into Indian wheats. The fixation, isolation and testing of new wheats from these series is not likely to be a long process. Experience continues to confirm the paramount importance of standing power in any further progress in the improvement of the Indian wheat crop.

III.—Other Investigations.

Tobacco.—Substantial progress has been made during the year in the tobacco investigations at Pusa.

The only type of Indian tobacco found suitable for cigarettes in Bihar, when cured by the country method, is one known as Type 28. This was grown on a fairly large scale on the Dholi Estate during the last tobacco season and the crop was cured on the ground—an assistant being lent from Pusa to show the factory staff how to proceed. The yield of cured leaf to the acre was very satisfactory and the product was taken over by the Indian Leaf Tobacco Development Company at Dalsing Serai. This year a larger area is being grown on the Dholi Estate. The spread of the cultivation of this kind is now a matter of price. If the growers are able to obtain a premium for this kind from the Company to repay them for the extra care required in the curing process the area will expand. On the other hand, it must be remembered that there is no competition

on the part of the local trade for this tobacco when grown for cigarettes and at present the Company can to all intents and purposes make its own terms. This year a good deal of seed of this kind has been distributed not only to planters in Bihar, but also to Government farms in the Central Provinces and in the United Provinces.

Experience in tobacco growing in Bihar discloses the fact that every year the growers suffer a large amount of loss of crop and waste a good deal of labour. Both can be avoided. These losses are due to the primitive methods of growing the seedlings, to the frequent loss of the majority of the first sowings and to numerous casualties after transplanting, resulting in a very uneven crop. Experiments were made during the past year with a view to remedy this state of affairs. The seed beds were partially sterilized by making fires on the surface before sowing and also by heating the upper soil in pans. The results were exceedingly promising—the seedlings on the partially sterilized beds were much stronger than the rest and were ready for transplanting about a week before the others. These experiments are being extended and other methods of partial sterilization such as steaming are being tried.

A paper dealing with the results obtained on the inheritance of characters in this crop has been written by the Personal Assistant. This work is of interest from several aspects. It was undertaken with a view of obtaining some general idea of the best method of attacking the problem of the improvement of the quality of the Bihar tobaccos—more particularly from the cigarette tobacco standpoint. From the practical point of view the possibilities of obtaining better tobaccos by breeding have been shown to be certain, and several promising sorts have been isolated during the progress of the work. From the scientific aspect it has been shown that, provided proper precautions are taken, the inheritance of quantitative characters, such as those relating to the size and shape of a tobacco leaf, follows the Mendelian scheme. In this paper the results obtained on the inheritance of the factors concerned in the size and shape

of the leaf are new, and mark an advance in the application of modern methods of plant breeding to crops of economic importance.

Gram.—The selection experiments with gram referred to in the last annual report have been continued. The season was not very favourable to gram as the seed bed was too wet due to the storms of November followed by heavy rains at flowering time. The high yielding white gram, which in 1912 was valued at Rs. 5-8 per cwt. f. o. r. Bombay, again did well at Pusa and seed of this and of some of the other kinds is being tried in Bihar and also on various Government farms in the Central Provinces and in the United Provinces.

Fibres.—A good deal of work was done during the year on fibre plants, particularly with regard to the inheritance of characters in *Hibiscus Sabdariffa*. This is being continued and it is expected to publish the results obtained during the coming year.

In the case of *Hibiscus cannabinus* the promising kind, known as Type 3, has been grown for fibre with satisfactory results. Seed of this kind will be offered to the various Provincial Departments of Agriculture during the present year.

Methods of pollination.—Observations on the methods of pollination in the various crops grown at Pusa have been continued and an effort will be made next year to publish the results.

Indigo.—In consequence of the decision to close the Sirsiah Experiment Station, the work on indigo formerly carried out there was transferred to the Botanical Section at Pusa at the end of the last financial year. Six small tubes of selected indigo seed were received from Sirsiah and these have been sown at Pusa. In addition, a large number of indigo experiments were started at Pusa in October 1912 in continuation of those begun the year before. The indigo industry, which is now in a declining condition, presents three problems for immediate solution. In the first place, the best methods of growing Java indigo so as to avoid the

loss of plant during the late monsoon due to " wilt " have to be worked out at an experiment station and then tried on the large scale on estates. Secondly, the best way of growing good seed of this crop in Bihar has to be discovered. At present, the seed supply is erratic and often far below the demand. Lastly, the methods of pollination have to be investigated with a view to deciding whether or not there is any scientific basis for the idea that this crop will repay the application of modern methods of selection and breeding. Considerable progress has been made in this work, particularly on the successful treatment of " wilt " and some results of undoubted value have been obtained. If possible, a separate report will be submitted early in 1914 dealing with the position of the investigations to date.

In connection with the work on indigo some reference should be made to the relations which have arisen between the Botanical Section and the Bihar Planters' Association. Since the Tirhut Exhibition was held at Pusa in January 1912, two addresses have been given to the Planters' Association at Mozafferpore dealing with the various improvements in local agricultural practice discovered in the Botanical area at Pusa in the course of the plant breeding work. These addresses, which were given at the request of the President, were well received and were, during the present year, published in the form of a bulletin entitled *Some Aspects of the Agricultural Development of Bihar.* Particular attention has been drawn to the value of hot weather cultivation in Bihar, to the annual losses due to want of drainage combined with erosion by rain wash, to the value of green manuring with *sunn* on the higher well-drained lands and to the use of labour-saving devices in the shape of small cultivators, lever harrows and improved ploughs.

IV.—Work done in Europe.

While on leave in Europe during the present year a certain amount of work was accomplished relating to the investigations in progress at Pusa and Quetta.

Agricultural Exhibitions.—Two large Agricultural exhibitions were visited, namely, the Royal Agricultural Show at Bristol and the Agricultural Exhibition at Munich in connection with the 'Oktoberfest.'

At Bristol some attention was paid, at the request of the Government of India, to the Overseas section—a new departure at the Royal Show in which the assistance of India was requested. Government decided not to participate at present but to ask two of the officers of the Agricultural Department to submit a joint report on the nature and objects of this section of the Exhibition. Exhibits were sent not only by the Self-governing Dominions (Australia, Canada and South Africa), but also by some of the Local Governments of the Dominions (Victoria, South Australia, Queensland and Western Australia) and by various Crown Colonies (Federated Malay States, British West Indies and British Guiana) and Rhodesia. In addition, various Companies dealing with emigration sent large exhibits, such as the Orient Line, the Dominion Settlement Association, the Canadian Government Emigration Department, the Canadian Northern Railway and the Canadian Pacific Railway. India was represented by a small stall sent by the Department of Agriculture, Bengal. The feature of the Overseas section as a whole was the inducement held out to emigrants—labourers, small holders and farmers—to settle in the new countries. The exhibit of products was evidently a subsidiary matter and it was clear that the advantage to India of participating in such an Exhibition in the future would be almost negligible in proportion to the trouble and expense involved.

Some time was devoted both at Bristol and at Munich to the modern developments in the manufacture of agricultural implements which is not without interest to India at the present time now that the Co-operative movement is spreading and the purchasing power of the cultivator has been increased by union and is no longer limited by his individual resources. At Bristol particularly and to a less extent at Munich, the feature of the display of implements

was the attention that is now being paid to the design of chief machines of light draught suitable for small holdings. A large number of small firms are engaged in the business and as the tendency in Great Britain is all in favour of small holdings, it seems probable that among the implements designed several will be found of use under Indian conditions. There were also many designs of portable petrol engines of small power for agricultural purposes including several threshers driven in this manner. The contrast between the small handy implements exhibited at Bristol and the collection of heavy agricultural machines at the recent Allahabad Exhibition was most striking.

Fruit packing.—Some attention was paid to the progress in the methods of packing fruit which is going on in connection with the produce sent to the London market. Some new packing materials were observed which are said to be very successful. These will be tried during the next year at Quetta and if found useful under Indian conditions will be brought to the notice of those concerned. It is quite probable that the cost of the present packages used at Quetta can be materially reduced and work in this direction is already in progress.

Experiment Stations.—Visits were paid to the four leading experiment stations in Great Britain—Rothamsted, Merton, Cambridge and Long Ashton. Very important work is in progress at Rothamsted, particularly on the factors influencing the fertility of soils and on the accurate determination of the products of assimilation in leaves. The feature of the plant breeding station at Merton in addition to the great variety and interest of the problems in hand is the high standard of cultivation reached both in the green houses and also in the numerous plots outside. Everything was thriving and well grown and one left with the impression that Great Britain possesses at least one modern experiment station characterised by real vitality. At Cambridge some time was spent with Professor Biffen in going over the plant breeding work on wheat and other crops which is now being greatly extended. An area

of land is being taken up for plant breeding purposes only, where the new varieties can be grown on a moderately large scale before being issued to the farmers. At Long Ashton near Bristol, a visit was paid to the Fruit Experiment Station in connection with the National Fruit and Cider Institute where a good deal of useful and interesting work has been done.

At most of the experiment stations in Great Britain extensions are in progress due to the funds set free by the Development grant. There is a marked tendency to endow agricultural investigations, to make the work continuous and to render it independent of what may be described as irregular and precarious support. The progress of the work under the Development Commission cannot fail to be of interest to all concerned with the task of improving the rural economy of India.

Wheat.—The opportunity was taken of several consultations with Mr. Humphries relating to the work in hand on the improvement of Indian wheats and the testing of the resulting samples. Visits were also paid to Mark Lane and the Baltic and the most reliable advice available in London was obtained as to the best way of introducing the new Indian wheats to the trade and marketing them to the greatest advantage. In all these matters Mr. Humphries was invaluable and he spared no pains to help the work in every way.

Publications.—A memoir on the inheritance of characters in tobacco was passed through the press in England with a view of comparing the work done in Calcutta and London and the corresponding cost. The result was to show that printing and illustration work is both cheaper and better in London while the labour of passing a paper through the press there is materially reduced.

Drainage.—The opportunity was taken of examining the methods of drainage in use in northern and central Italy and the care taken in these tracts in freeing the arable land of excess water. The method adopted is identical in principle to that worked out in the Botanical area

at Pusa, but in some details the Italian practice is an advantage. Steps are being taken to improve the Pusa method. The progress that has taken place in Italian agriculture during the last fifteen years is remarkable not only in general cultivation, but also in the spread of the co-operative movement. In many respects the conditions in Italy are not dissimilar to those in India and might easily repay detailed investigation.

V.—The Development of the Fruit Industry of Baluchistan.

The present report deals briefly with the work accomplished up to September 1912 relating to the development of the fruit industry of Baluchistan and with the chief lines of progress which experience suggests should be taken up in the near feature. It will be convenient to deal with the matter under the following main heads :—

Fruit and Agricultural Experiment Station.

An area of 25 acres of land with two *shabanas* of water of the large Sirkhi *karez* has been acquired by the Local Administration for the purposes of a fruit and agricultural experiment station on the Sariab Road about two miles from Quetta. The purchase was completed at the end of August 1911 (with the exception of one of the *shabanas* which was bought in June 1912) and since that time the farm buildings, offices and boundary wall have been erected, a well sunk, and considerable progress has been made in the laying out of the area in large terraces to facilitate irrigation. Three artesian bores have been sunk which give a total flow of 1,500 gallons per hour. A fourth bore is being put down to the water-bearing gravel at the 150′ level. An experiment in pumping from one of these artesian bores by means of an oil engine is in progress and will, it is expected, be completed shortly. At the present time, bricked water channels are being laid down and various other permanent improvements are in progress. Four pairs of Sibi cattle

have been purchased and a supply of implements collected. Progress has been made in the enlistment and training of the staff.

While most of the year has been taken up with preliminary spade work in connection with the laying out and levelling of the land previous to planting in November 1912, nevertheless a few results have been obtained. These are as follows :—

1. *The raising of nursery stock.*—The usual practice in Quetta up to the present, both in the Government gardens and in those of zamindars, in the raising of new trees has been to side-bud on two or three years' old stocks, the time taken in raising budded trees being two or three years. This year it has been found that if the seedling stocks were ring-budded in May and June, strong plants can easily be raised ready for planting within a year of the sowing of the seed of the stock. This is an important matter from the point of view of the revenue of the station and also from the standpoint of a large supply of good trees for replacing the old fruit gardens and for new planting. The supply of good and abundant planting material for the Province will in future years be a simple matter.

2. *The saving of water.*—The most important direction in which the agriculture of Baluchistan can be improved is in the saving of water and in making the greatest possible use of the present supplies. Attention has therefore been paid to this matter and results of importance have been obtained. By means of surface cultivation after the winter rains, it has been found possible to conserve the moisture in the soil to a very considerable extent and this can easily be applied to the growth of wheat and fruit trees. It has already been taken advantage of in the raising of nursery stock and in the growth of tomatoes. The soil of the valley is also suitable for furrow irrigation so that there is every prospect that by means of this method of watering, combined with clean weeding and surface cultivation, the present water supply of the valley can be shown to be able to produce at least twice the crops grown at present.

3. *The use of green manure in Baluchistan.*—Closely bound up with the conservation of moisture by surface cultivation and improved methods of irrigation is the supply of organic matter to the soil so as to increase its water-holding capacity. The geological history of the Province suggests that the soil is likely to be deficient in organic matter. This is confirmed by the local agricultural practice in which large quantities of manure are employed. The easiest method of adding this organic matter would be to grow some leguminous plant on the winter rains and when irrigation water is available and to turn this into the ground in April and May. The best crop for the purpose appears to be clover (*shaftal*) and accordingly some of this was put down in the autumn of 1911. Two or three cuts were obtained, which were sold to the Military Dairy, and the next crop was ploughed in as a green manure. The soil was greatly improved and it is practically certain that this crop will prove of great value in the Province, as it will not only improve the tilth and fertility of the soil, but also increase its water-holding capacity. A good deal of work remains to be done to find out the best methods of utilising this crop to the greatest advantage in the rural economy of the Province.

4. *The arrangement of fruit gardens.*—At the present time there is little or no arrangement in the fruit gardens in the valley and there is no separation of the trees into early, mid-season and late so as to facilitate watering and picking. There is no order or method so that a vast amount of unnecessary work is done in gathering the fruit and a good deal of water is wasted, as it is almost impossible to water a few trees without irrigating the whole garden. To obviate this, a beginning has been made in the collection and propagation of the best local varieties which will be planted out systematically. A sufficient supply of trees has been raised this year and care has been taken to keep accurate nursery records. A few French trees have been imported and it has been arranged to introduce all the best kinds from the South of France next February so that

the experiment station will possess a wide range of kinds, many of which it is hoped will be useful for propagation. This collection will be of the greatest use in the future development of fruit-growing in Baluchistan.

The Renovation of a Neglected Fruit Garden.

At the request of the Hon'ble Colonel Ramsay, C.S.I., C.I.E., Agent to the Governor General in Baluchistan, the southern portion of the Quetta Residency compound—an area of about 14 acres—was taken up as an experiment in renovating and replanting a derelict and neglected fruit garden. The land was taken over in October 1911, but a supply of convict labour was not arranged for till July 1912 so that this portion of the work has been delayed to some extent. Progress, however, has been made and this garden is being cleared, graded and the land brought into cultivation. As much as possible will be sown with *shaftal* this autumn and some of the plots will be ready for planting in trees in November 1913, the trees, which are ready now, being grown on in the nursery till that date. Notwithstanding the bad state of this area when taken over, there is little doubt that it can be made to yield a good return provided the water supply from the Barnes and Tari *karezes* can be ensured and the present thefts of water prevented. The revenue of the year is expected to reach at least Rs. 1,000 which is more than the working expenses. This should increase considerably when the new trees come into bearing and till that time a large revenue should be obtained from *shaftal*.

During the present year two results of importance were obtained in this area :—

1. *Tomato cultivation.*—Except in the private garden of the Agency Surgeon (Colonel Duke), the cultivation of tomatoes does not appear to be understood in Quetta although the crop is easily grown. It was therefore decided to try an experiment on a large scale with tomatoes trained on the two-branch system of Colonel Duke combined with furrow irrigation, as is practised at Pusa in the case of

tobacco. A preliminary trial of this system was carried out at Pusa last cold weather, where it proved a great success. On repeating the experiment at Quetta, the assistant in charge failed to raise a proper supply of seedlings by the time I arrived in May, so that a miscellaneous collection of seedlings left over in the gardens of various vegetable-growers had to be collected and the best made of this very inferior planting material together with a small supply of plants raised by the Overseer of the Residency Garden. The plants, however, did better than was expected and up to the time of writing (September 19th) the income from an area of four-tenths of the acre has exceeded Rs. 600. About half of the fruit is not yet ripe and of this a good deal has already been destroyed by the early frosts. There is no doubt, however, that if the tomato seedlings are raised at Sibi and planted in good time for the whole crop to ripen before the cold weather sets in, the income from an acre of tomatoes (sold at Rs. 3 per maund) would result in a clear profit of Rs. 1,500 per acre at least. The amount of water required is small and the expenses of training and pruning are not very great. The experiment will be continued next year and will be conducted by Hira Lal, the Overseer of the Residency Garden. The experiment has greatly impressed the local growers, and has attracted a good deal of attention. Several vegetable-growers propose to take up this method of growing the crop next year.

2. *The transport of tomatoes.*—In order to test the demand for Quetta tomatoes in the Calcutta market, twelve crates of fruit have been exposed for sale in the shop connected with the Great Eastern Hotel. Packed in crates holding 24 chip baskets, each holding one seer, the fruit reached Calcutta in excellent condition and was sold at twelve annas per basket. This leaves a margin of profit of Rs. 12 per crate of 24 seers.

3. *The yellowing of peach trees in Quetta.*—In the Civil Station of Quetta, the peach trees have, as a rule, very yellow foliage, often accompanied by excessive gumming. Such trees are said to die very quickly and this experience has

been confirmed by the death of many trees this year which showed these symptoms markedly last year. Over-watering and want of cultivation do not appear to be the cause of the yellowing and there are no indications of insect or fungoid disease. The early symptoms appear to be identical with the mysterious disease in the Eastern United States known as "Peach yellows," but the later symptoms of "Yellows," namely, premature ripening and reddening of the fruit with very poor flavour, are not developed. The yellowing is therefore fortunately not due to "Peach yellows." The next point to settle was whether or not the yellowing is caused by unfavourable soil conditions. Evidence was obtained during the summer indicating that the yellowing is due to the soil and that green manuring with *shaftal* may prove to be the best remedy. The yellow condition does not appear to be propagated by buds taken from affected trees, as both these trees and trees with green, healthy foliage gave rise to budded plants which appeared equally healthy. Experiments are in progress to test these ideas still further and definite evidence on the subject should soon be forthcoming.

Packing Experiments.

During 1911, a considerable amount of attention was paid to the improvement of the present methods of packing fruit at Quetta with a view of making the most of the present railway transport to India. The results obtained were dealt with in detail in the progress report of 1911 and can be shortly recapitulated as follows :—

1. Returnable packages for long journeys in India are unsuitable on account of the cost of returning the empty boxes and on account of the frequent mistakes on the part of the Railway Company in charging the wrong rates.
2. All packages must be designed to prevent as far as possible thefts in transit by the railway servants. The frequent occurrence of these thefts is a great obstacle to the extension of the Quetta

fruit trade as the expense and trouble of sealing numerous small packages is very great. It should be possible, if the matter is strongly represented to the Railway Board, to fix the responsibility for the packages on certain individuals and to prevent cases of thefts in a manner which would not make it worth while to continue these malpractices.

3. Except for short distances, cheap non-returnable packages seemed to be the best, especially in the case of small consignments to private individuals.

4. The packages most likely to be useful at Quetta appeared to be (*a*) non-returnable peach crates with 3″ and 3½″ chip cubes for the five seer railway rate. (*b*) Grape boxes suitable for the 2½ and 5 seer rates. (*c*) Non-returnable and returnable crates holding 24 chip baskets, each holding about one seer, the whole coming under the 30 seer rate. (*d*) Cheap climax baskets for selling fruit at the markets and at the various gardens.

5. The best packing material appeared to be *sunn* fibre imported from Oudh in pressed bales. This was cheaper and better than cottonwool and also easier to handle than wood wool which also received an extended trial. Care must be taken to use only clean well-retted *sunn* for this purpose.

During the present year a supply of these packages likely to be of most use in Quetta was made to order by the British Basket Company of Glasgow and shipped to Karachi. They were placed on the market at Quetta and sold at prices sufficient to cover all expenses including that connected with their sale. All the packages were taken up by the Indian fruit traders and about half the supply imported was sold. In all about £45 worth was supplied to the trade. It is expected the rest will be disposed of

next year and that the expenses connected with the importation will be completely recovered.

Experiments on the transport of grapes were taken up on a small scale in 1912 and it was found possible to send these to Calcutta packed with *sunn* in the non-returnable crates. The prices realized were Rs. 2 per seer which gives a very good return. Unfortunately the supply of cork dust ordered for the grape packing experiments did not arrive in time, but it is hoped to carry out tests with this material later on.

As a result of the experiments of 1911 and 1912 it may be said that most of the fruit packing questions have been solved and that packages better and cheaper than anything to be produced locally have been brought to the notice of the trade. For a year or two it will be necessary for Government to finance the supply of these packages after which it will be best to get an agency established in Quetta and for the trade to supply itself. Mr. Bliss has agreed to take up the agency when the time comes.

Future Work.

As most of the initial difficulties connected with the scheme have now been overcome and a beginning has been made with the work, it is not out of place to indicate the lines of future progress and to sum up the present position. The prospects of success of the fruit scheme are exceedingly favourable and there appears to be no reason why the project should not fulfil the expectations of its promoters. As results accumulate and as the water-saving devices become known, there is no doubt that the lessons of the experiment station will be taken up at once. The present methods are haphazard and all that is done after the planting of the trees is to apply water in the most wasteful method that could be devised and take whatever crop happens to be produced. None of the zemindars realize the possibilities of the valley and there is no doubt that an area under fruit and other crops properly managed would revolutionise the present practices. What is possible in

the valley has been clearly indicated by the tomato experiment of this year and equally striking results are possible with other fruit crops. What is wanted is the application of scientific principles to crop production and the only way of doing this is for Government to continue to act as the pioneering agency and to show the way.

As regards the future the following are the chief lines of work which remain to be developed :—

1. *Propagation.*—More attention will be necessary in the raising of young trees for planting. A greater range of stocks is desirable and the trees should be trained while in the nursery. A large selection of kinds should be raised so as to prolong the season of each fruit and the losses to the Province in the past from the distribution of bad stock should be prevented in the future.

2. *Improvement in yield and quality.*—Great advances in the yield and quality of fruit are necessary before the industry can be developed. At present the yield of fruit per acre is very small and the quality is not good. Varieties which require good cultivation like peaches are very short-lived and the prevalence of the yellowing of the leaves indicates that these trees are not properly grown. Pruning is hardly understood at present and the trees carry only a small proportion of poor fruit compared with what is easily possible.

3. *Water conservation.*—The great need in agriculture in Baluchistan is the saving of water. In this connection the preliminary work which has been done on surface cultivation, furrow irrigation and the increasing of the water-holding capacity of the soil by green manuring should be developed and the possibilities of water-saving demonstrated by actual examples.

4. *Vegetable growing.*—Good vegetables can be grown at Quetta at a time when there are no supplies to be had in the plains. It has been demonstrated that tomatoes can be sent to Calcutta at a good profit and there is little doubt that this line of work can be extended considerably in the future.

5. *Fruit packing.*—The work on fruit packing should be continued, particularly with regard to grapes for which there is likely to be a great demand in India at good prices. Moreover, grapes grow well in Baluchistan and appeal to both Europeans and Indians in Hindustan. The importation of packages should be supervised for a year or two until the trade is in a position to supply itself. Possibly later on cool vans will be available for the Calcutta market and whole van-loads can be sent to that city.

6. *Collection of varieties.*—The work on the collection of the best indigenous varieties together with good kinds from France and the United States should be continued till the experiment station is really well stocked. The best of these trees should be propagated and the young trees made available to the public.

7. *Training.*—In addition to the purpose of the experiment station as a model for the Province it can easily be made use of as a training ground for *malis* and zemindars. The object aimed at should be to pass a number of men every year through the station and to train them in all branches of the work. In this way the standard of agriculture will gradually rise and fruit-growing will be placed on a higher plane. Detailed proposals on this subject are being submitted to the Local Administration.

VI.—Programme and Publications.

Programme of work for 1913-14.

1. *Training.*—The training of advanced students in this section will be continued.

2. *Plant breeding and plant improvement.*—During the year the following crops will be studied:—wheat, tobacco, oil-seeds, fibre plants and indigo.

(*a*) *Wheat.*—The production of improved and rust-resistant types by selection and hybridisation will be continued. The co-operative experiments on the influence of the environment on the milling and baking qualities of Indian

wheats, which are being conducted in collaboration with Mr. H. Martin Leake, Economic Botanist to the Government of the United Provinces, will be continued. The botanical survey of the wheats of Baluchistan and the agricultural survey of the wheats of Bihar will be completed.

(b) *Tobacco.*—The production of new varieties by selection and hybridisation will be continued, as well as the testing and curing of the varieties already isolated. The detailed study of the inheritance of characters in tobacco is being continued by the Personal Assistant.

(c) *Oil-seeds.*—The study of the oil-seeds of India will be continued on similar lines to those adopted in the investigations on wheat.

(d) *Fibres.*—The isolation and testing of pure races of the fibre plants of India will be continued. The study of the inheritance of characters in these crops is being continued.

(e) *Fruit.*—The fruit experiment at Pusa will be continued on the lines laid down in the first Fruit Report. During the months May to September the work connected with the development of the fruit industry of Baluchistan will be continued.

Publications.

Some progress was made in the publication of results and a certain number of completed pieces of work were written up during the year. A good deal, however, remains to be done to bring the publication of results up to date.

The following papers were written or published during the year :—

1. Some Aspects of the Agricultural Development of Bihar. *Bulletin No. 33, Agricultural Research Institute, Pusa.*
2. The cultivation and transport of tomatoes in India (with G. L. C. Howard). *Bulletin No. 1, Fruit Experiment*

Station, Quetta. (Reprinted in the *Agricultural Journal of India,* Vol. VIII, Part III.)

3. Some improvements in the packing and transport of fruit in India (with G. L. C. Howard). *Bulletin No. 2, Fruit Experiment Station, Quetta.* (Reprinted in the *Agricultural Journal of India,* Vol. VIII, Part III.)
4. The improvement of crops (with G. L. C. Howard). *Agricultural Journal of India,* Vol. VIII, Part II.
5. Yield and quality in wheat (with H. Martin Leake and G. L. C. Howard). *Agricultural Journal of India,* Vol. VIII, Part II.
6. Natural root-grafting. *Agricultural Journal of India,* Vol. VIII, Part II.
7. The improvement of Indian wheat—a paper read at the Punjab Agricultural Conference, Lyallpur, November 4th, 1912 (with G. L. C. Howard). *Agricultural Journal of India,* Vol. VIII, Part I.
8. Sesam, *Sesamum indicum,* L. *Die Züchtung der landwirtschaftlichen Kulturpflanzen,* Bd. V, Paul Parey, Berlin, 1912.
9. Deccan-order Ambari-Hanf (*Hibiscus cannabinus,* L.). *Die Züchtung der landwirtschaftlichen Kulturpflanzen,* Bd. V, Paul Parey, Berlin, 1912.
10. Hibiscus Sabdariffa, L. *Die Züchtung der landwirtschaftlichen Kulturpflanzen,* Bd. V, Paul Parey, Berlin, 1912.
11. Indischer Sunn-Hanf (*Crotalaria juncea,* L.). *Die Züchtung der landwirtschaftlichen Kulturpflanzen,* Bd. V, Paul Parey, Berlin, 1912.
12. Kugelfruchtige Jute (*Corchorus capsularis,* L.). *Die Züchtung der landwirtschaftlichen Kulturpflanzen,* Bd. V, Paul Parey, Berlin, 1912.
13. Langfruchtige Jute (*Corchorus olitorius,* L.). *Die Züchtung der landwirtschaftlichen Kulturpflanzen,* Bd. V, Paul Parey, Berlin, 1912.
14. Studies in Indian Tobaccos. No. 3. The inheritance of characters in *Nicotiana tabacum,* L. (G. L. C. Howard). *Memoirs Department of Agriculture in India* (Botanical Series), Vol. VI, No. 3.
15. On the inheritance of some characters in wheat—I (with G. L. C. Howard). *Memoirs Department of Agriculture in India* (Botanical Series), Vol. V, No. 1.

REPORT OF THE IMPERIAL MYCOLOGIST

(E. J. Butler, M.B., F.L.S.)

I.—Charge and Establishment.

I was on privilege leave for the first six days of the year, since when I have remained in charge of the section Mr. F. J. F. Shaw continued to hold the post of Supernumerary Mycologist until April 21st, when he left to take up his acting appointment as Government Mycologist, Madras. He was confirmed in the service during the year. Mr. J. H. Mitter, Second Assistant, officiated as Assistant Professor of Botany in the Agricultural College, Lyallpur, until the end of August when he was appointed Assistant Professor of Botany, Muir Central College, Allahabad. The vacancy thus caused was filled by promotion in order of seniority, S. Pasupati Iyer coming in as Second Clerk. All the staff have worked well.

II.—Training.

Babu K. C. Banerji, B.A., L.Ag. (Nagpur), a stipendiary student from the Agricultural Department, Bihar and Orissa, was under training until August 17th.

III.—Diseases of Plants.

The investigation of diseases of plants caused by fungi, and the more routine work of dealing with enquiries regarding the identity and treatment of crop diseases, formed, as usual, the greater part of the work of the section.

(1) *Rice diseases.*—The disease of this crop in Eastern Bengal, locally known as *ufra*, has assumed serious proportions. The districts known to be affected are Noakhali, Tippera and Dacca. In these districts paddy is the staple food crop, occupying over 70 per cent. of the cultivated area or some $2\frac{1}{2}$ to 3 million acres, with an outturn of about

1,100,000 tons of clean rice. Both the main winter crop, or "aman," paddy and the autumn, or "aus," crop suffer, but the damage is much greater in the former, as its long growth period allows of a progressive increase of the parasite. The most severely attacked varieties are those grown in the lower lands, subject to early inundation and where transplantation is not possible. A large part of the rice grown is of this class; the transplanted varieties, grown on higher land, occupy a smaller area and do not seem to get the disease. The lower land is under water for a considerable period every year and gets little cultivation, being often allowed to remain covered with weeds and stubble after harvest until the first spring showers. The organism, an eelworm of the genus *Tylenchus*, mentioned in last year's report as the suspected cause of the disease, has been found during the year to be constantly present in every case and attempts to induce the disease experimentally by inoculating healthy paddy with it have been fully successful both at Pusa and at Dacca. The worm is one previously undescribed and, up to the present, has been found only on paddy suffering from *ufra*, or in the stubble from the diseased crop. On the living plant it is active, feeding and reproducing freely; after the death of the plant it assumes a passive condition, lying coiled up within the sheaths and glumes, and in this state can remain alive, if kept dry, for many months. Activity is resumed, at Pusa, about April. The length of the life cycle is not yet known, but there are several generations during the growth period of the crop and the rate of multiplication appears to be very considerable.

Experiments have been undertaken, in collaboration with the Bengal Department of Agriculture, to devise methods of fighting this disease. Paddy probably suffers less than any other cereal from epidemic diseases and every effort will have to be made to check the spread of *ufra*. The losses caused by it are very great; in some cases the crop is not worth harvesting, in many others it is reduced to half or a quarter of the normal. In the districts referred

to nothing else can replace paddy as a food crop, and in certain parts the distress that has been caused is undoubtedly very great. The most hopeful method of attack appears to be the destruction, by burning, of the stubble from diseased fields, and the Bengal Department has arranged to expend a considerable sum in experiments in this direction. A small area has been selected near Comilla for further experiments, especially in cultivation and trial of varieties. The enquiry will be treated as the most important on which this section is engaged, and efforts will be made in particular to fill up the gaps in our knowledge of the life history of the parasite. An account of the work up to date has been included in a Bulletin on rice diseases, now in the press, and a less technical paper has been contributed to the Agricultural Journal.

Amongst other diseases of rice investigated during the year, "bunt" (caused by *Tilletia horrida* Tak.) was found to be widely prevalent in Burma, though usually in such small amount as to cause little loss. Its detection was the result of complaints received from Germany, of the presence of black spores in rice meal imported from Rangoon and Moulmein. The disease is one which may well increase in virulence as time goes on and it is useful to know that we have a safe and assured preventative in a seed steep, similar to one employed against the allied wheat bunt.

The false smut of rice [caused by *Ustilaginoidea virens* (Cke.) Tak.] was found to occur throughout a large part of the rice-growing tracts of India. It does rather more damage than bunt, but still not enough, usually, to repay treatment. This is fortunate, for no treatment is known, and experiments to follow out the life history of the fungus and ascertain how it infects the host plant have failed. These experiments will be continued as opportunity offers.

Probably more important than either of the two last mentioned diseases is that caused by *Sclerotium Oryzæ* Catt., which I found in Burma and Madras and which also occurs at Pusa. Its symptoms are obscure and it can

easily be overlooked, as its chief effects are to cause excessive late tillering of the plant and partial sterility of the ear. Its further investigation was taken up by Mr. Shaw, who has established the parasitism of the fungus and studied its behaviour in artificial culture. The disease is probably one of the causes of the condition known in Burma as *gwa-bo*, in which an undue proportion of the ears are light or partially sterile and which is said to represent a very great aggregate loss. I found on local examination that most of the loss was attributable to insect pests, chiefly borers, and that fungus injury was probably too slight to be of economic significance. Mr. Shaw has prepared an account of his investigation, which is in the press as a Memoir.

(2) *Sugarcane diseases.*—The " red rot " of sugarcane (caused by *Colletotrichum falcatum* Went.), which is the worst fungus disease of this crop in India, has been under study at Pusa for a number of years. Various difficulties which were met with have delayed the writing up of the results, but sufficient information has now been obtained to justify publication. A Memoir, prepared jointly by myself and A. Hafiz Khan, Third Assistant, to contain the results of experimental work since 1906, has been submitted for publication. The experiments have been chiefly directed to obtain information as regards methods of infection. It has been securely established that the most common method in Northern India is by the planting of infected setts from a previously diseased crop, a method that has been recently controverted in Louisiana and the West Indies. The failure of sett selection which has been observed on several occasions, has been shown to be due to the presence, in severely diseased crops, of a percentage of infected canes which do not show the characteristic warning symptom of reddening in the pith. In attacks of ordinary severity this percentage is negligible, but in severe epidemics it is advisable to avoid the use of any cane from the diseased crop for seed. It has been further shown that sound setts may be infected after planting, though in

Northern India the parasite appears to die out rapidly in the soil and there is not much danger from this source, unless there is carelessness in allowing rotten canes to lie on the fields after harvest. Infection by air-borne spores through wounds in the stem, such as those caused by boring insects, was found to be uncommon, though accepted as the usual method in most other countries where the disease is prevalent. The leaf scars at the joints, left after the leaves are removed in stripping or wrapping the cane, are stated by some observers to admit the parasite, but it was found that this did not occur if the leaf had reached maturity and came away readily. On the other hand the shoot and root eyes at the joints can be infected and through the latter, especially, the fungus has no difficulty in gaining an entry into the cane pith. The most probable origin of the infective matter was found to be a form of the fungus which is parasitic on the midrib of the leaf, and which had been overlooked by most observers.

From these results, backed by field observations, it is concluded that the most important precaution to be taken against the disease is to select the setts used for planting, so that only those with unreddened pith are used. The effect of sett selection in keeping the disease from reaching epidemic severity has been very satisfactory in several Bihar estates and elsewhere, and it should be made a routine practice. In very severe attacks sett selection may fail, and it may be necessary to introduce new seed from outside. Care must be taken at the same time to remove early cases of the disease, in order to avoid risk of infection through the shoot and root eyes, and also to destroy rotten canes and trash after harvest, so as to prevent infection of the setts at or after the time of planting. Finally it is pointed out that the "thin" canes, in which India is so rich, are almost immune to the disease; that the comparatively little damage caused by red rot in Java may be due to the fact that many of the best Java canes are the progeny of crosses between Indian thin canes and the locally grown thick kinds; and that there is every

reason to hope that similar results can be obtained in India by hybridization.

Three minor sugarcane diseases, caused by undescribed species of fungi, have also been under study, and the work was advanced sufficiently by the end of the year to allow of the results being written up. One of these, occurring at Samalkota and Jorhat, is possibly that referred to in last year's report as resembling *sereh*. They will be more fully dealt with in the next report.

Phytophthora investigations.

Mr. J. F. Dastur, First Assistant, completed his investigations of a new species of this destructive genus, which was found attacking castor, and published a detailed description of it in the Memoirs. The parasite causes the most injurious fungal disease of this crop known, and is especially harmful to eri-silk worm breeders. On seedling plants it causes a "damping off," which may affect 30 to 40 per cent. of the seedlings; older plants are attacked chiefly in the leaves. A full account of the morphology of the parasite is given, the chief interest centring in the discovery of a new type of reproduction. Shortly before the publication of the paper, this discovery was anticipated by a British Mycologist, working with an allied species. The growth of the fungus in artificial culture was successfully attempted. A very complete series of inoculation experiments was carried out, potato, tomato, brinjal, *til* and several other plants proving susceptible to attack.

The study of *Colocasia* blight (caused by *Phytophthora Colocasiæ* Rac.) was commenced by Mr. G. S. Kulkarni, Mycological Assistant of the Bombay Department, when a student at Pusa in 1909, and completed by myself during the year. We published a joint account of it in the Memoirs, giving details of the characters of the disease and the morphology and biology of the fungus. The intensity of the attack is closely dependent on the character of the monsoon, being worst in wet years. In addition to the already known damage caused by rotting the leaves, the

parasite was found to infect the corms and to cause considerable injury after the crop is lifted. Pure cultures were grown in 1912, and a large series of inoculation experiments carried out, but the species is much more restricted in its choice of hosts than the castor parasite.

A serious outbreak of potato blight (caused by *Phytophthora infestans* de Bary) occurred in the Gangetic Plain, where the disease has not been reported since 1902. The outbreak is probably to be attributed to the fact that the local seed supply failed, in a great measure as a result of damage caused by the potato moth. A large import of hill seed occurred at the beginning of the cold weather and no doubt introduced the fungus, which is endemic in the hills. Mr. Dastur has obtained pure cultures of the parasite and is testing its temperature relations, as this appears to be likely to prove the most important factor in its control.

Rhizoctonia.

The results of Mr. Shaw's work on this genus of soil-dwelling parasites, referred to more fully in last year's report, were published during the year. He has continued his investigations, particularly with forms parasitic on lucerne and Delphinium. It is evident that great confusion of species exists in the published literature of the genus and his researches should do much to clear this up. It is of interest to record that a severe attack of opium poppy blight, which has generally been supposed to be caused by *Peronospora arborescens*, was found to be due last season to *Rhizoctonia.* It is hoped that Mr. Shaw will be able to continue his work on this, after his return from Madras.

Wheat rust.

Wheat rust was prevalent in Bihar last season and some interesting observations were made in selected areas at Pusa, on the influence of soil moisture and density of growth on the disease. Orange rust (*Puccinia triticina*)

appeared early and spread uniformly, without much relation to position in the field or density of the crop. Later on it became more intense where the crop was heaviest and tallest, but was soon masked by yellow rust (*Puccinia glumarum*). This did not appear in any quantity until the crop was nearly full grown but then developed with great intensity wherever the crop was tall and dense. Black rust (*Puccinia graminis*) was late in appearing and did not show any regularity in distribution. In February and March, Dr. Leather kindly made some determinations of soil moisture and air humidity in two plots, one with a light, thin crop where rust was slight, and the other where the crop was heavy and rust severe. The soil moisture was much better in the latter, especially from the 3rd to the 6th foot in depth. The humidity was taken within the crop, about 4 inches above ground level, the first test, lasting for 7 to 8 hours, being made on February 14th, in dull and humid weather. In the thin crop the relative humidity was 57·3 per cent. and the mean air temperature was 26° C. In the heavy, badly rusted crop, the relative humidity was 76·7 per cent. and the mean air temperature 23° C. A second test was made on February 21st, the crop having been much laid by a storm on the 15th and the day being fine with a dry west wind blowing. No appreciable difference was found in the two plots.

The intensity of the attack of yellow rust and the later stages of orange rust thus varied directly with the soil moisture and the air humidity within the crop. The early stages of orange rust would not be exposed to the influence of the latter factor, as at that period the crop is too small to cover the ground closely. By the time black rust appears, transpiration has much diminished, as the crop is then almost ripe; the air temperature is higher and the drying west winds have usually set in. Hence the late rust is not much exposed to differences in air humidity. Of the two factors the immediately important one is apparently the humidity of the air within the crop, but

this again is connected with the soil moisture, as it must depend largely on the density of the crop and the vigour of transpiration.

Ground-nut diseases.

The cultivation of ground-nut in the Bombay Presidency underwent a progressive decline between 1895 and 1903. This decline was attributed in 1902 by Mr. Mollison, then Inspector General of Agriculture, to the extension of disease in the crop. In that year I found a fungal disease (caused by *Septoglœum Arachidis* Rac.) was doing great damage. Attempts to check it by spraying failed, and the only hope seemed to lie in the introduction of early maturing and resistant varieties. Recently the cultivation of ground-nut has again expanded and various reports led me to believe that this disease had diminished. On visiting the Presidency I found that this was the case to such a degree, that I had considerable difficulty in finding any attacked plants. Coincident with the decline of the disease there has been a change in the varieties of ground-nut grown. The Bombay Department of Agriculture introduced a number of foreign varieties in 1901 and the following years, and these have almost replaced the old varieties, except in the Poona District. It is difficult to avoid the conclusion that the introduction of the new varieties is connected in some way with the decline of the disease, though a direct connection is hard to establish, since the old varieties, still grown near Poona, are now equally free from attack. It would, however, be interesting to know how far natural crossing has occurred between the new and the old varieties, as in this there is a possible explanation of the difficulty. I think that Mr. Mollison and the Bombay Department are entitled to claim the credit of having successfully fought one of the worst diseases of cultivated crops which I have seen in India. The area under ground-nut in the Deccan rose from 56,000 acres in 1902-03, to nearly 200,000 acres in 1911-12.

Cotton and Sesamum wilts.

A wilt disease of cotton (caused by *Fusarium vasinfectum* Atk.) is probably the worst fungal disease of this crop in the United States and has been reported from most other cotton-growing countries. It has been known for some years that a similar disease occurs in the Central Provinces. Sesamum is also attacked by an allied disease, and an attempt was made to isolate the parasites concerned, establish their identity and make as complete a study of the diseases as possible. I found cotton wilt extends over a large area from the Central Provinces to Belgaum, being especially prevalent in the Berars, where it has been carefully observed by Mr. Clouston. Sesamum wilt extends from Hoshangabad, where Mr. Evans gave me much useful information regarding its distribution and field characters, into parts of Bombay. Fungi of the genus *Fusarium* were isolated from both crops and have been maintained in pure culture. The first attempts to test their parasitism failed, possibly because the season was already too far advanced, and the work is, consequently, being repeated.

Anthracnose of Sisal hemp.

This disease was investigated by Mr. Shaw, who established the parasitism of the fungus (*Colletotrichum Agaves* Cav.) previously suspected to be its cause. It was found to infect species of *Agave* readily and to produce a characteristic leaf disease. An account of the work was published in the Agricultural Journal of India, January 1913. Collecting and burning diseased leaves, and spraying with Bordeaux mixture, are measures which are recommended as likely to prove efficacious in checking the disease.

Indigo disease.

The work mentioned in last year's report was continued, but led to no useful results. Neither Mr. Shaw nor myself, working independently, was able to obtain any evidence that the so-called disease is caused by any definite parasite. Some half a dozen species of fungi were isolated from

plants in various stages of "disease," but none of these proved capable of reproducing it. As they were mostly belonging to the class of weak parasites, capable of infecting the host plant only when the latter has been weakened by some other agency, it was concluded that the cause of the trouble lies deeper. Since it is practically certain that it is not mycological, the enquiry was abandoned, and a note giving a summary of the work, and the reasons for this step, was submitted to the Bihar Planters' Association, and circulated amongst the members.

Forest tree diseases.

This section, as usual, assisted the Forest Department in examining and reporting on specimens of fungus diseases of forest trees, mostly received through the Imperial Forest Botanist. As this is rather a specialised branch of mycology and as the work of the section has grown too much to allow of all enquiries being dealt with equally fully, arrangements were made with the Forest Botanist, defining what assistance we were prepared to give. Under present circumstances, it will not usually be possible to undertake any definite research into the causes of undescribed diseases of trees, but where the parasite is already known, or is allied to known ones, assistance can be given. The Forest Botanist was supplied with all the information available in this section on the obscure "spike" disease of sandal.

Green parasites.

Mr. Shaw continued his investigation of the flowering plant *Striga*, which is parasitic on the roots of jowar, sugarcane and other *Gramineæ* in India. He also took up the study of an allied plant, *Sopubia,* which attacks several cereals. When the work was commenced, little was known regarding these interesting plants, but the result of work on South African species of *Striga* has recently been published. It is still necessary to compare the Indian species

with those of South Africa and the investigation of *Sopubia*, about which nothing whatever is known, is equally important. The economic aspect has not, as yet, been considered in South Africa, and this side of the enquiry is of primary interest to us.

Other plant diseases.

The section has, as usual, been consulted by the Scientific Department of the Indian Tea Association on several occasions. It was also consulted by the Australian Prickly Pear Commission, on the diseases of that plant in India, and by the Agricultural Department of British East Africa, on coffee leaf disease. A serious disease of betle pepper, which causes great loss in certain parts of India, is being investigated and appears to be caused by an undescribed species of *Colletotrichum*, of which the perfect stage has been obtained in culture. Experiments in checking anthracnose of plantains were continued. The treatment of oat smut by formalin steeping was successfully demonstrated on several estates in Bihar, and is being taken up satisfactorily. Work with *Pennisetum* smut was continued, but the life history of the fungus has not yet been worked out. A disease of maize, hitherto unknown outside Java, appeared at Pusa last year. It is exceedingly destructive in Java, but our knowledge of the life history of the parasite [*Sclerospora Maydis* (Rac.) Butl.] is imperfect and an attempt was made, and is being continued, to obtain fuller information on this point. An account of it was published in the Memoirs. The "damping off" of seedlings (caused by *Pythium de Baryanum* Hesse) was found for the first time in India last year, though common in temperate climates. Its study in culture was undertaken, and an account of it published in the Memoirs. The rotting of stored potatoes is being investigated at the instance of the Economic Botanist, Bihar and Orissa; much of the loss has been found to be due to *Rhizoctonia*.

IV.—Systematic Work.

The additions to the herbarium continued steadily, the total number of mounted sheets added being 780. Most of these were Indian, the most important outside contributions being from Berlin and Manilla. A considerable number of parasitic fungi were named for the college collections of the Provincial Departments of Agriculture, for other colleges, and for the Forest Research Institute. Large collections of Indian fungi were distributed to interested persons. The *Hypocreaceæ* of our collections were kindly named by Mr. T. Petch, Government Mycologist, Ceylon. The perfect stages of the rusts of sugarcane, cotton and fig were discovered during the year and will be described shortly. Mr. Shaw has commenced the systematic study of some soil fungi.

V.—Programme of work for 1913-14.

(1) *Research and experimental work.*—The continued investigation of the disease of paddy, known as *ufra* in Bengal, will be regarded as the most important individual item of the work of the section. Other diseases of paddy will be studied as occasion arises.

Of sugarcane diseases, the study of which will be continued, the most important in view is the *sereh*-like disease at Jorhat and elsewhere. It is hoped to ascertain definitely whether it is caused by a fungus, and, if so, whether it is identical with a new disease of which an account will shortly be published.

The wilt diseases of cotton and sesamum are major diseases, the investigation of which will be continued.

The work on potato blight may also require to be treated as an investigation of importance, if the disease again recurs, and the same applies to the opium poppy blight, referred to in the body of the report.

Besides the investigation of the last-mentioned disease, Mr. Shaw may be able, on his return from Madras, to progress with his sutdy of some green parasites, of which

a more precise knowledge than is at present available is greatly required. His work on soil fungi is likely to extend over a considerable period and is not of such immediate importance as the other enquiries, but it probably has a bearing on such questions as the decomposition of green manures, and may give valuable results.

Minor investigations are those of the anthracnoses of plantain and betle pepper, smut of *Pennisetum*, maize mildew and further work on diseases of castor.

(2) *Training.*—This will be continued on the lines indicated in the Prospectus. Short courses will also be given if any students of the Institute wish to attend.

(3) The routine work of advising on plant diseases will be continued and assistance will be given as usual to the Provincial Departments of Agriculture, the Forest Department, Planters' Associations and the general public.

(4) It is hoped to make further progress with the publication of descriptive lists of Indian fungi, and, if time permits, the preparation of a 5th part of "Fungi Indiæ Orientalis" will be taken up. This will be the most important item of the systematic work.

VI.—Publications.

1. Preliminary Report on Ufra disease of Rice in Noakhali District, E. J. Butler. *Bull. of the Bureau of Agricultural Intelligence and of Plant-diseases,* 3rd year, No. 7, July, 1912, p. 1661.
2. The Morphology and Parasitism of *Rhizoctonia,* F. J. F. Shaw. *Mem. Dept. of Agri.,* Bot. Ser., IV, No. 6, September, 1912.
3. Anthracnose of Sisal Hemp, F. J. F. Shaw. *Agri. Journ. of India,* VIII, No. 1, January, 1913.
4. Report on Mycology for 1911-12, E. J. Butler. *Annual Report of the Board of Scientific Advice,* April, 1913.
5. On *Phytophthora parasitica* nov. spec., a new disease of the Castor oil plant, J. F. Dastur. *Mem. Dept. of Agri., India,* Bot. Ser., V, No. 4, May, 1913.

6. Colocasia blight, caused by *Phytophthora Colocasiæ* Rac., E. J. Butler and G. S. Kulkarni. *Mem. Dept. of Agri., India*, Bot. Ser., V, No. 5, May, 1913.
7. *Pythium de Baryanum* Hesse, E. J. Butler. *Mem. Dept. of Agri., India*, Bot. Ser., V, No. 5, May, 1913.
8. The Downy Mildew of Maize [*Sclerospora Maydis* (Rac.) Butl.], E. J. Butler. *Mem. Dept. of Agri., India*, Bot. Ser., V, No. 5, May, 1913.
9. Diseases of Rice, E. J. Butler. *Bull. 34, Agri. Res. Inst., Pusa* (*in the press*).
10. Ufra disease of Rice, E. J. Butler. *Agri. Journ. of India*, VIII, No. 3 (*in the press*).
11. A Sclerotial disease of Rice, F. J. F. Shaw. *Mem. Dept. of Agri., India*, Bot. Ser., VI, No. 2 (*in the press*).
12. Red Rot of Sugarcane, E. J. Butler and A. Hafiz Khan. *Mem. Dept. of Agri., India*, Bot. Ser., VI, No. 5 (*in the press*).

REPORT OF THE IMPERIAL ENTOMOLOGIST

(A. J. Grove, M.Sc.)

I.—Charge and Establishment.

I held charge of the section from July 1st, 1912, until the 29th, when Mr. H. Maxwell-Lefroy, Imperial Entomologist, returned from leave. Mr. Lefroy, however, resigned his post on the 30th of November 1912 and I took over charge from him on that date to officiate under orders of the Government of India until a new appointment was made, and have continued to hold charge since then. The First Assistant, Mr. C. S. Misra, was away on privilege leave from January 2nd until April 2nd, 1913. He has continued to be in charge of the field work on the Pusa Farm and the Botanical area, and has also instructed the long course students. The giving of two short courses in Lac Cultivation and the arranging of the general lac work has been in his hands. As well as this routine work, he has undertaken investigations on the occurrence of bollworms and their parasites in the experimental plots on the farm, arranging for the despatch of parasites to Egypt, and has also continued his work on economic *Aleurodidæ* and *Coccidæ*. The Second Assistant was on privilege leave from the middle of November to the end of December. He has remained in charge of the Insectary and assisted in the special investigation on indigo "Psylla." He has also done much useful work with the European and Indian bees. Mr. Dutt was on privilege leave from January 2nd to March 2nd, 1913. He has remained in charge of the economic collections and correspondence, a part of the General Collection (*Hymenoptera*), and the preparation and distribution of coloured plates and lantern slides, and has taken up a study of Hymenopterous parasites of crop pests. Mr. D. Nowrojee took privilege leave for 18 days during October and November 1912. He has remained in charge of the General Collections and has continued in-

vestigations on the biology of beetles affecting stored products. Mr. M. N. De has continued in charge of the Silk House and has carried out the hybridisation work with Mulberry silkworms and has also assisted in the preparation of sample silk pieces with both Eri and Mulberry Silk.

II.—Training.

The private student deputed by the Department of Agriculture, Travancore, continued his training until March 14th when he returned to his State for three months to study the particular pests of the State and returned on July 4th to work up the material he had collected and to continue his training. A student, deputed by the Assam Department of Agriculture, was admitted on November 1st, 1912, for training. A student from the Agricultural College, Giza, Egypt, was admitted on August 1st at the request of the Government of Egypt for a three months' training in practical entomology. Nine students have attended the short courses in Sericulture. Seven students attended the two short courses in Lac Cultivation, five in June and two in October.

III.—Research.

The investigation into the so-called "Psylla" disease of indigo was carried on and the practical results have been published. General enquiries into the biology and habits of insect pests have been continued and among those studied may be mentioned Painted Bug, Anar Butterfly, Termites (White-ants) and Bollworms and their parasites. An investigation has also been commenced, at the request of the Punjab Government, into methods for preserving wheat stored in bins from damage by beetles.

IV.—Insect Survey.

Additions have been made to the general collections during the year. Specimens of *Orthoptera* sent to Mr. Kirby, *Homoptera* to Mr. Banks, *Ichneumonidæ* to Mr.

Morley and *Psyllidæ* to Mr. Crawford for identification have been received back. Specimens of *Coleoptera* (*Longicornia*) were sent to Mr. Gahan and *Cantharidæ* to Dr. Wellman for identification.

V.—Provincial Work.

With the appointment of Entomological Assistants to the Provinces, Pusa is less in touch with the work done in the Provinces except in such cases where the Entomological Assistants submit monthly reports and where direct guidance is asked for. Also with the appointment of a European Entomologist to the Government of Madras, the necessity for controlling the work in that Presidency from Pusa no longer exists. It is to be regretted that Pusa is not in closer touch with the provincial work and the matter is under consideration, for it is advisable that there should be as complete co-ordination of the entomological work in India as possible in order to prevent duplication.

In the Central Provinces the rearing of Eri worms was continued and an effort was made to study sugarcane borers and the effect of growing maize as a trap-crop for them. In Bihar and Orissa the campaign against the greasy Cut-worm, *Agrotis ypsilon*, was successfully carried out. Arrangements were also made to make more traps locally and to start work against the Cut-worm at Bhagalpur and Colgong during the following year. Potato storage experiments were made at Bettiah, Bihar, Bhagalpur and Colgong, and demonstration godowns were started at Colgong and Bhagalpur. The rearing of Eri worms was continued and eggs were distributed to the local zemindars. In Baroda, work on checking the "Katra" and the sesamum stem-borer was continued. Field demonstrations were also given in several villages to check cotton bollworms, the sesamum stem-borer and the tobacco stem-borer. Arrangements were also made to start lac cultivation on *Babool* in the State and to procure *Babool* brood-lac locally.

VI.—Special Investigations.

(1) *Insecticides.*—Various proprietary preparations have been received for trial and reported upon. Many of these are found either to fall short of what is claimed for them or to be unsuitable for use in India.

(2) *Sericulture.*—The experiments with European Univoltine races have been continued and have given satisfactory results. The eggs which, as reported last year, were sent to places in the hills, where the temperature is not so extreme as on the plains, for storage during their dormant period, have turned out very well and given as good results as those which were cold-stored in a refrigerator in Calcutta. The hybridisation work with mulberry worms has been continued and more satisfactory results have been obtained.

Eri silkworms were again reared with good results, except during the hot dry months when conditions are extremely unfavourable. With this industry there is great need for better organisation both with regard to the distribution of seed and the disposal of cocoons. Efforts have been made to make arrangements whereby small rearers can dispose with advantage of the small quantities of cocoons they produce, but much closer co-operation among the rearers will be necessary before this can be done satisfactorily. The necessity, too, of a certain supply of reliable eggs has been felt this season and it is hoped that arrangements to overcome this difficulty may be made in future.

Requests for mulberry and castor seeds, disease-free Mulberry and Eri eggs, samples of cocoons, yarn, cloth, pamphlets, etc., have been received from numerous applicants, whose requirements have been supplied as far as possible. Sample pieces of both Eri and Mulberry silk cloth have been prepared and dyed with alizarin colours to show Indian weavers the possibilities of these silks.

Exhibits were sent to Muzafferpore, Bankipur, Malda, Banjettia, Ellore, Calcutta and Bangalore.

(3) *Lac culture.*—Two short courses in lac cultivation were given. The collection of lac insects from Forest

Officers for the determination of the species of lac insects has been continued and the series from most ranges are now almost complete. *Ber* and *Kusumb* plants, inoculated with lac insects, were again sent to Japan. Brood-lac was sent to Ceylon. Numerous enquiries about lac cultivation were received and answered. The Bulletin on the "Lac Cultivation in the Plains of India" is being translated into Hindi and Urdu. Experiments to determine other food-plants of the *Ber* lac have been carried out and are still in progress.

(4) *Apiculture.*—The experiments with European bees have been continued, but this year particular attention has been directed to obtaining fertilized queens. A large number of experiments were made and in all twenty-five queens were reared, but of these only two were successfully fertilized. Although this result seems rather poor, a large amount of valuable experience was obtained and it is hoped that when the proper season again comes round more successful results will be obtained.

The experiments with the Indian bee, *Apis indica*, were continued, but much progress was still impossible owing to the lack of suitable appliances. A foundation mill has now been obtained and it is hoped that during the next honey flow a satisfactory test of their honey-gathering qualities will be made.

VII.—Demonstration.

Owing to lack of funds no new coloured plates were issued during the year. Additional copies of the plates already published were issued to the Directors of Agriculture, Bengal and the Central Provinces, and to the Principal, Agricultural College, Nagpur. Sets of coloured lantern slides were supplied to the Director of Agriculture, Bengal, Principal, Agricultural College, Nagpur, Entomological Assistant, Baroda State, and the Assistant Professor of Entomology, Agricultural College, Lyallpur. The Department of Agriculture, Bombay, have indented for a large supply of coloured plates and arrangements have been made to supply these.

A demonstration of the use of spraying machines was given at various Indigo Factories in Bihar in connection with the treatment of indigo "Psylla."

VIII.—Correspondence.

Much time is still devoted to dealing with the numerous applications received for information, advice and the like, in the many branches of entomological endeavour dealt with by this section, but such correspondence is still given the greatest possible attention because of its great utility to officials and the general public. Eighty parcels of specimens were received from various applicants during the year and the fullest information possible was supplied in each case.

IX.—Visitors.

The Hon'ble Sir K. G. Gupta, K.C.S.I., Member of the Secretary of State's Council, and the Hon'ble Sir Charles Bayley, K.C.S.I., Lieutenant-Governor of Bihar and Orissa, visited the section in November and January respectively. Dr. L. H. Gough, Entomologist to the Department of Agriculture, Egypt, worked in the Laboratory in September and visited Baroda and Cawnpur during August with the First Assistant, to make arrangements for the despatch of bollworm parasites to Egypt. Mr. A. Alfieri visited Pusa from July to September on behalf of the Khedivial Agricultural Society of Cairo in connection with bollworm parasites. Lala Bishembar Das, Assistant Professor of Biology, Government College, Lahore, worked in the Laboratory from October to December. Lala Madan Mohan Lal, Assistant Professor of Entomology, Agricultural College, Lyallpur, spent three weeks in the Laboratory during October. The Entomological Assistant of Baroda visited Pusa in April to discuss his programme of work for the ensuing year. Mr. N. N. Pillai, Weaving Expert to the Government of Bengal, visited the Silk House during April. Mr. Cook, Principal of the Weaving School, Benares, inspected the dyeing work carried out in the Silk House.

X.—Programme of work for 1913-14.

As previously, investigations into crop pests and suggesting of remedial measures will be continued, and accounts of their life-histories, etc., will be published as material accumulates. The short courses in lac cultivation and Eri and Mulberry silk cultivation will be given as formerly, and also the training of students in general entomology. The cultivation of lac for experimental and demonstration purposes will be continued. The work with Mulberry silkworms will be carried on. Eri worms will be reared and help and advice on both Eri and Mulberry cultivation will be afforded as far as practicable. Experiments with European bees, especially from the point of view of queen raising, will be continued. It is hoped that it will be possible to test the honey-gathering qualities of the Indian bee, *Apis indica*, during the coming spring. Insecticides and apparatus, sent in for trial, will be tested and reported upon. The field experiments with wheat and sugarcane will be continued. If funds are available more coloured plates will be published and the work of preparing lantern slides will be continued. Where desired, help will be given to the Provincial Assistants in their work, and in case of serious outbreaks of pests special assistance will be given. The special investigations with insects attacking stored wheat will be continued as also the experimental work with cotton bollworm.

XI.—Publications.

1. Tetriginæ (Acridiinæ) in the Agricultural Research Institute, Pusa, with descriptions of new species. Dr. ~~H~~. L. ~~Gough~~. *Mem. Dept. of Agri., India*, Ent. Ser., Vol. IV, No. 2. Hancock J
2. The Big Brown Cricket (*Brachytrypes Achatinus*, Stoll). C. C. Ghosh. *Mem. Dept. of Agri., India*, Ent. Ser., Vol. IV, No. 3.
3. Life-histories of Indian Insects.—IV (Hymenoptera). G. R. Dutt. *Mem. Dept. of Agri., India*, Ent. Ser., Vol. IV, No. 4.

4. Inquiry into the Insecticidal action of some Mineral and other Compounds on Caterpillars. H. M. Lefroy and R. S. Finlow. *Mem. Dept. of Agri. in India*, Ent. Ser., Vol. IV, No. 5.
5. Cultivation of Lac in the Plains of India. C. S. Misra. *Bull. 28, Agri. Res. Inst., Pusa.* (*Second Edition in the press.*)
6. Directions for the Cultivation of Eri Silk. *Bull. 29, Agri. Res. Inst., Pusa.* (*Second Edition in the press.*)
7. Litchi Leaf Curl. C. S. Misra. *Agri. Journ. of India*, Vol. VII, Pt. III, July, 1912.
8. The "Psylla" disease of Indigo in Bihar. H. M. Lefroy. *Agri. Journ. of India*, Vol. VIII, Pt. I, January, 1913.
9. The Red Spider on Jute. C. S. Misra. *Agri. Journ. of India*, Vol. VIII, Pt. IV (*in the press*).
10. Life-history of Helicomitus dicax. C. C. Ghosh. *Bom. Nat. Hist. Soc. Journal* (*in the press*).
11. Instructions for rearing Univoltine Mulberry Silkworms. M. N. De. *Bull. 39, Agri. Res. Inst., Pusa* (*in the press*).
12. Life-histories of Indian Insects.—Lepidoptera. C. C. Ghosh. *Mem. Dept. of Agri. in India*, Ent. Ser., Vol. V, No. 1 (*in the press*).

Publications in preparation :—

Memoir on Indigo Psylla.

Memoir on Orthoptera.

Memoir on Coleoptera.

Memoir on Heterocera.

Memoir on Hemiptera.

Memoir on Insects Injurious to Indian Agriculture, revised edition.

Memoir on Indian Economic Aleurodidæ.

Bulletin on Fruit Pests.

Bulletin on Bees and Bee-keeping.

Vernacular translation of Bulletin No. 28 (revised edition) on the "Cultivation of Lac in the Plains of India."

REPORT OF THE IMPERIAL PATHOLOGICAL ENTOMOLOGIST

(F. M. Howlett, B.A., F.E.S.)

I.—Administration.

I was in charge of the section throughout the year, but spent two months in September and October on privilege leave.

Of the work which is summarised in this report, I owe not a little to the stimulus of frequent correspondence, conversation and collaboration with many medical officers more or less directly engaged in entomological work. The probable severance of these relations in the near future is to me a source of regret.

II.—Veterinary Work.

In January I circularized all Provincial Directors, enquiring whether there was any veterinary research in progress which I could assist from the entomological side, or any special direction in which they would suggest that entomological investigation should be prosecuted. The majority replied that the services of an entomologist were not at present required; Madras, Burma and the Central Provinces referred to the collection of possible Surra-carriers, and the Central Provinces also mentioned the parasites of sheep.

Major Holmes proposes an investigation of the insect carriers of Surra at Kathgodam. An assistant has been given special training in order that he may assist by carrying on the rearing of Tabanidæ and other blood-sucking Diptera which will be required in this enquiry.

A large collection of Ticks, mostly from Veterinary Officers of the different provinces, has been consigned to Professor Nuttall at Cambridge, there to be examined and identified in connection with Professor Nuttall's monographs on the subject which are now appearing.

An attempt was made to repeat the observations of Hindle and Merriman on the smell-reactions of Ticks (*Argas* and *Hyalomma*), but I was unable to obtain the same results. The matter is one of considerable interest, and I propose to return to it.

III.—Agricultural Work.

This was practically confined to the subject of fruit-flies of the genus *Dacus*.

A poison-spray method, which depends for its efficacy on the habit of the peach-fly (*D. Zonatus*) of sucking tentatively at any little drop of moisture on a leaf, was tried with excellent results. The proportion of affected peaches in the sprayed plots was approximately 2 per cent. over the whole period of picking, in place of the usual 45—60 per cent. The cost of the method is very small compared with the value of the crop, and should this year's results be confirmed by another season's work, they will have a very considerable commercial importance.

In the course of experiments on the chemotactic reactions of male fruit-flies I have found that these insects are strongly attracted by certain compounds allied to Eugenol ($C_{10}H_{12}O_2$). These compounds thus constitute a means of detecting the presence of the flies in a given locality with a degree of certainty quite unattainable by any ordinary method of observation.

Using this chemical test in the course of a tour in March through Bihar, the United Provinces, the Punjab, and the North-West Frontier Province, I found that the North-Western limit of the distribution of peach-fly practically corresponded with the South-Eastern limit of successful peach-growing.

Mr. and Mrs. Howard have shown that under the climatic conditions which obtain at Pusa it is possible to grow first-rate peaches. That peaches are not largely or profitably grown in the Southern and Eastern portions of the Gangetic Plain and in various districts in Southern

India is, I believe, due very largely or entirely to the abundance of peach-fly, 50 per cent. or more of the crop being almost invariably maggotty. It thus appears probable that the application of the poison-spray method may result in opening up, for the profitable cultivation of sound peaches, large areas where such cultivation is at present impossible owing to the ravages of the fly.

IV.—Medical Work.

The two genera concerning which information was chiefly desired by the Medical Department were *Stegomyia* and *Phlebotomus.*

A course of instruction in the identification, breeding and general observation of *Stegomyia* was given in July to Medical Officers engaged in the "Stegomyia survey." The life-histories of all the species occurring at Pusa have been worked out in their main features. Careful observations have been carried on throughout the whole year on the seasonal prevalence of the different species, and it has been established as a practical certainty that all species are normally in the habit of tiding over periods of drought as dry eggs, even though these periods may be of six months or even longer duration.

Anti-*Stegomyia* operations have been carried out at Pusa, with a very marked result on the numbers of these mosquitos, which in past years have been invariably very troublesome in the rains. This year it is rare to find them in the bungalows.

The methods adopted have been the filling up with earth or plaster of Paris of all known or probable breeding-places, particularly holes in trees and cut bamboos, and the simultaneous provision of "trap-breeding-places" in the form of bamboo-joints filled with water which are emptied out as soon as larvæ make their appearance in them. I regard this trapping method as a distinct advance on mere indiscriminate destruction, and with modifications it might be found a valuable aid in anti-malarial operations.

Coloured plates were prepared illustrating all stages of the life-history of the different species of *Stegomyia* and allied genera occurring at Pusa, and a set of maps was also constructed, largely from information received from Medical Officers on the Stegomyia survey, showing the known distribution of the different species in India. These plates and maps, together with specimens of the mosquitos in different stages and other exhibits, were sent at the request of the Medical Department to the International Exhibition at Ghent to form a part of the Indian exhibit in the section of Tropical Medicine and Hygiene. A typical collection of mosquitos and other human parasites was also sent to Dr. Marzinowsky of Moscow.

A large number of observations have been made as to the action of different chemical substances on the eggs and larvæ of mosquitos (*Stegomyia scutellaris*, *Myzomyia rossii*, and *Culex fatigans* and *microannulatus*).

It has been found that ordinary powdered Calomel (mercurous chloride) has many of the properties of the ideal larvicide, and this substance certainly merits a more extended trial to ascertain its cost and efficacy under field-conditions. The action is comparatively slow, but sure and apparently lasting, while the amount which it is necessary to use is so minute that treated water is in no way harmful or uncomfortable for ordinary use by men or cattle.

Observations have also been made on the method of feeding and the nature of the food and digestion of mosquito-larvæ, and on the respiration and oxygen-consumption of larvæ and pupæ. Methods of colouring mosquitos for identification in flight-determination have been tried with success as far as permanence and ease of identification are concerned, both carmine powder and gentian-violet giving good results.

The breeding of West Indian "Millions," obtained in the first instance from the Officiating Sanitary Commissioner of the United Provinces, though quite successful under "semi-domestic" conditions, has been a failure when

the fish have been transferred to large *pucca* tanks. This seems to be owing to the attacks of the larvæ of large Dytiscid water-beetles which are common here, and which destroy the young fry and even the adult fish. It is probable that the native *Haplochilus* is, under Indian conditions, at least as effective a larva-destroyer.

With regard to sand-flies (*Phlebotomus*) the life-histories of *Phlebotomus papatasii*, *P. argentipes*, and *P. minutus* have been worked at.

Attention was mainly directed to *P. minutus*, which is the commonest species at Pusa, and a large amount of time has been spent in the difficult task of discovering natural breeding places. The preliminary results of this enquiry were presented in a paper read at the Malaria Conference at Madras.

By combining these results with those obtained in a series of experiments on the predilections of the larva and of the fly for various foods and for different hosts, it appeared probable that there was some connection between the fly and the wall-lizards or Geckos commonly found on tree-trunks and the walls of bungalows. Subsequent observations have shown that this supposition is correct, and that there is undoubtedly a close connection at several points between these reptiles and *P. minutus*. In a paper contributed to the " Indian Journal of Medical Research " I have put forward the view that the " real " hosts of this sand-fly are lizards, and that the connection with man may be of a secondary nature.

Attention has lately been directed to the hosts attacked by *P. argentipes*, as little is known of the biting habits of this species, but no very definite results have yet been obtained. *P. papatasii* will be most easily investigated in the Punjab or North-West Frontier Province, where it is far commoner than at Pusa. The results obtained through the excellent work of Professor Newstead and Captain Marett in Malta will probably be found applicable to India, and can be taken as a basis for further investigation of the habits of this species.

At the end of the rains I spent some time in Poona in company with Captain Morison, I.M.S., and inspected the breeding-grounds of Muscid flies which were suspected of a connection with a form of enteritis prevalent at Poona. Experiments on marked flies were carried out to ascertain how far the city trenches were responsible for the very great abundance of flies in the city and cantonments. An assistant was deputed to remain at Poona and assist Captain Morison in the investigation of breeding-places and the other entomological work necessary. An assistant was similarly deputed to assist Major Greig, I.M.S., in his investigation of typhoid fever at Puri, and the part played by flies in its transmission. In collaboration with the Medical Officer at Pusa observations are being made on the flies responsible for the cases of myiasis which are somewhat common in the district.

One assistant attended the malaria class, under Captain Hodgson, I.M.S., at Delhi. A large number of mosquitos and other insects, sent in mainly by Medical Officers, have been identified. I gave a series of lectures with practical instruction on methods of drawing and illustrating.

In November I had the pleasure of attending the Malaria Conference at Madras and read three papers :—

"The yellow-fever mosquito."
"The breeding-places of Phlebotomus."
"Insect psychology and its bearing on methods of control."

Two papers have been contributed to the first issue of the "Indian Journal of Medical Research" :—

"The natural host of Phlebotomus minutus."
"Insect life-histories and parasitism."

V.—Programme for 1913-14.

Fruit-flies and Parasitic Insects.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST

(C. M. Hutchinson, B.A.)

I.—Administration and Tours.

I held charge of the section throughout the year excepting three weeks' privilege leave in September, when Mr. Joshi was in charge.

The staff was considerably strengthened by the sanction of the following additional appointments :—

Supernumerary.—Mr. J. H. Walton, B.A., B.Sc., was appointed as Supernumerary Agricultural Bacteriologist, and joined this section on 25th October 1912.

Assistants.—Two posts of Assistants on Rs. 75—125 each were sanctioned; one was given to Mr. C. S. Ram Aiyer, B.A., an Assistant in this section; and the other to Mr. N. C. Bose, an Assistant in the Chemical Section. Mr. Bose was appointed in this section on 18th April 1913. Mr. N. Dayal Singh was appointed in this section, as Fieldman, on 1st May 1913.

Mr. Vishwanadham, Second Assistant, was on privilege leave from 25th March 1913 to 27th April 1913. Mr. Ram Aiyer, Third Assistant, was on privilege leave from 8th July 1912 to 20th August 1912.

The outside laboratory building was completed and work commenced in it in June 1913; Mr. Vishwanadham, Second Assistant, has been put in charge of this building. It is primarily intended for pot-cultures and work on ammonification and nitrification in soil media; an important feature is the locally made pressure sterilizer capable of sterilizing six large or twelve smaller sized culture pots simultaneously under 40 lbs. steam; this will also be available for use by the Mycological Section.

The compound attached to this building will be used for experimental plots; pits for growing rice under varying

conditions of water supply have been made and are now in use; green manure (sann) has also been grown for experimental purposes.

Tours.—To Muktesar to discuss various matters connected with bacteriological technique in India with the Imperial Bacteriologist.

To Muzafferpore to attend meeting of Bihar Planters' Association.

To Nagpur to examine soil conditions and obtain samples from sewage treated area.

To Bettiah to investigate potato disease.

To Sirseah to consult Mr. Bergtheil on the subject of indigo disease.

II.—Soil Bacteriology.

Nitrogen supply in the soil as affected by intervention of bacteria has been the principal subject of enquiry; in the previous year attention was confined to the conditions under which organic nitrogen of manures and residues is converted into ammonia and nitrates; this line of enquiry affords sufficient work to occupy the whole time of any establishment for many years, but it has been considered advisable to add to it an investigation of the natural conditions under which nitrogen is taken from the air and added to the soil in this country. This if carried out thoroughly would also involve a very large amount of work, but it seems advisable in dealing with such a question as soil bacteriology in this country, where no work on this subject has been carried out before, to make preliminary enquiries, however superficial, on similar important questions, in order to gain some idea of the most useful direction in which to pursue the subject more fully. This is the more necessary on account of the still early stage of development of soil bacteriology as a science, and the fact that many fundamental theories connecting bacterial action with soil fertility have not yet been accepted as axiomatic. It is perhaps unnecessary to emphasize the importance of the question of nitrogen fixation, but it may be pointed out

that there is very good reason for supposing that upon this depends the ultimate prosperity of a country, the mineral wealth of which not being commensurate with its agricultural area and population debars it from the purchase of adequate supplies of nitrogen from external sources. At the present time the need of nitrogen in India is becoming increasingly greater owing to the introduction of intensive cultivation, although up till now the soils of this country as a whole have been preserved from undue depletion by the generally superficial and extensive nature of the cultivation employed, which has prevented large crops from being taken off the land, after the reduction of the original virgin soil to the normal level of fertility by the growth of crops. At the same time deportation of nitrogen in the form of produce exported from areas in which it was grown has not been excessive, and in the case of rice much fertilization of the soil takes place by deposition of organic matter carried down from jungle tracts by the irrigation water. Nowadays, however, this state of affairs is being rapidly altered owing to the expansion of Indian trade, which not only transports foodstuffs from agricultural districts to feed the increasingly large populations of cities, but carries enormous quantities of produce out of the country, including not only cereals, oilseeds and fibres, but bones and hides which represent nitrogen collected from very extensive areas of land. If now, in addition to this constant drain upon the nitrogen resources of the soil, intensive cultivation is introduced, meaning the more rapid conversion of non-available plant food, especially nitrogen, into the available condition, depletion will certainly follow, differing in intensity from such a result in temperate climate as the average soil temperature in India differs from that in Europe, but in an even higher degree. This difference due to temperature has been observed and measured in this laboratory as affecting ammonification, nitrification, and the formation of carbon dioxide by oxidation of the organic matter of the soil, and is not one of a slightly higher degree, but may easily attain to an increase

in rate of one hundred per cent. or more; the concurrent loss of nitrogen is not to be measured, therefore, only by the increased crops taken off the land, but by losses in the form of ammonia and of nitrate washed out during the rains from fallows in well drained areas.

A further point must not be overlooked; on the credit side of the nitrogen account must be placed the addition of this element to the soil through the intervention not only of leguminous plants, but of nitrogen-fixing members of the soil flora such as Azotobacter and Clostridium; the physiological activity of these organisms, however, is strictly limited by soil conditions, and especially in the case of the former by the supply of carbohydrate food, so that should intensive cultivation, carried out without regard to this aspect of the case, lower the supply of organic matter beyond the optimum point for nitrogen fixation by the above-mentioned organisms, this source of nitrogen would be cut off, and the discrepancy already existing between the two sides of the account would be further increased, probably in geometric proportion.

During the past year Azotobacter has been found in all Indian soils examined, including those of such widely differing character as may be found in Sind, Nagpur, and Assam; pure cultures of *A. Chroococcum* from such various sources exhibited nitrogen-fixing power very similar to that recorded from European strains, its physiological activity depending upon appropriate supplies of water, air, lime and especially of carbohydrate food. It is intended to carry out a general survey of Indian soils to get some idea of the distribution of this and similar organisms and the conditions under which they may most readily carry on nitrogen fixation in these soils.

The green manuring experiment begun in collaboration with the Imperial Agriculturist during the previous year was carried on, and will continue in 1913-14. The successful use of a green manure crop was found to depend almost entirely upon the incidence of the rainfall succeeding the burying of the crop, partly owing to the loss of

soil moisture by transpiration during the growth of the green manure, and partly to the necessity for providing a considerable percentage of soil water to ensure the proper decomposition of the buried material. Further experiments during the current season include a special method of dealing with a green manure crop designed to avoid the loss due to want of sufficient soil moisture to ensure complete decomposition after burying; this method consists in hastening the initial stages of decomposition by steeping the cut crop in water and then fermenting it in heaps, under which conditions the less readily decomposed cell walls and lignified tissues are rapidly attacked by bacteria favoured by semi-anærobic conditions; the fermented material is then used in the same way as farm yard manure. The advantages of this method, in addition to the principal one of eliminating the uncertainty of the rainfall as a factor in decomposing the buried green material, include the possibility of applying the fermented manure at the best rate per acre and at the best time for producing its optimum manurial effects; at the same time it is not necessary to grow the green manure crop on the land which is to carry the "rabi" crop intended to benefit by its manurial effect; in some cases this might be of great advantage with regard to the depletion of the soil moisture consequent on transpiration during the period of growth of the green manure crop. This method of dealing with a green manure crop closely resembles the practice in indigo-growing districts of manuring tobacco and other soils with the refuse ("Seet") from the indigo factory, which is obtained by steeping the cut indigo plant in water for some 24 hours and subsequently allowing the sodden plants to lie in heaps in which fermentation goes on; the rotted material thus produced is generally applied to tobacco lands, the rented value of which depends almost entirely upon the local availability of the indigo "Seet."

The field experiments with green manure in 1912-13 included the growth of a "rabi" crop (wheat) on the experimental area. In no case was there any increase in

yield from the green manured plots, and in many there was a decided falling off. There can be no doubt that this result was due to the failure of the generally expected rainfall in September and October (locally known as the " Hathia ") as it was found on examination that the buried stems of the green manure had failed to undergo complete decomposition.

Laboratory experiments showed that the nitrate formed from the buried plant tissues increased in amount up to the end of eight weeks from the time of turning into the soil, provided the water supply was kept up to at least 16 per cent. of the soil weight, but after this period a steady diminution took place, so that after twelve weeks a smaller quantity of nitrate than that present at the end of the eighth week was invariably found. The cause of this loss was not discovered, although it may be conjectured that it was due to the demands of the soil organisms for nitrogen, but its invariable occurrence is interesting as helping to explain the already well-known fact in field practice that too long an interval between the burial of a green manure and the sowing of the succeeding " rabi " crop is prejudicial to the latter so far as any improvement which may be expected from the use of the former is concerned.

The results of the first year's experiments on green manuring will be published in the form of a Bulletin.

Further work on the occurrence of bacterio-toxins in soil, their relation to infertility, and the action of tillage, drainage, and manurial application in neutralizing them, was carried out.

Biological analyses of various soils were made and further modifications of the method introduced; this subject is still in a very early stage of development, especially so far as interpretation of results is concerned, but it is hoped that further experience and modification of the method will lead to its successful application to the solution of various soil problems. At present it is possible to determine the optimum moisture content of a soil for

certain biological processes necessary for fertility, to ascertain approximately the organic manures most suitable for application, with the important reservation that the sample experimented on may not be truly representative of the area to be treated: this source of error is greatly minimised by the use of large samples and the introduction of the method of using soil media in place of inoculating liquid media with small samples of soil; thus in the old method one gram of soil was generally used as inoculum and the biologic activity of the soil as a whole was judged therefrom, whereas in the method now used, estimations of nitrifying and ammonifying capacity and efficiency, and general biologic activity, are made with samples varying from 400 grams to 1,200 grams.

III.—Special Enquiries.

(1) *Sewage Farms.*—At the request of the Principal of the Agricultural College, Nagpur, a series of investigations was commenced with a view to determining the effects of the application of sewage upon the biological condition of the soils of the College Farm. I visited Nagpur and inspected the farm soils and the sewage installation, and discussed with Mr. Allan and Mr. Plymen, the general arrangement of the experimental plots to be put under treatment. An arrangement was made for sending periodic samples to Pusa for examination, and at the same time Mr. Plymen agreed to carry out chemical analyses to determine nitrate at Nagpur.

(2) *Rice.*—An experiment was arranged to determine the effect of soil toxins upon the growth of the rice plant; this was in connection with the work of the Imperial Mycologist upon the "Ufra" disease of this crop, as it was considered possible that the incidence of this disease might depend upon adverse soil conditions. Rice was grown in pots in soil to which large quantities of mustard cake were added, it having been found that the initial stages of decomposition of this manure give rise to bodies which are toxic to plants. The pots were arranged so that

in one set lack of drainage should allow of accumulation of the toxins produced, whilst in the other continuous percolation removed them in solution. The results completely verified expectation, as not only was growth seriously interfered with in the undrained pots, but the root formation in the drained set showed that the toxins carried down by the percolating water had inhibited root growth in the lower soil, whereas in the undrained series more root development took place below than above. No symptoms of "Ufra" appeared, but Dr. Butler has now demonstrated conclusively the connection between this disease and the presence of nematodes in the plants, nor does it appear that soil conditions adverse to healthy growth render the plants more liable to attack.

(3) *Tobacco.*—The work on Tobacco Wilt in the Rangpur District was concluded and a Memoir on the subject published in the Bacteriological Series.

(4) *Indigo.*—Plants of Java variety were grown and kept under observation for symptoms of wilt in order to determine a possible bacteriological origin of this disease; this work will go on through current season.

(5) *Potato Rot.*—An extensive series of investigations was carried out, mainly by Mr. N. V. Joshi, First Assistant, as to the cause responsible for the very common rotting of tubers in store. The Economic Botanist to the Government of Bihar and Orissa, at whose instance this work was undertaken, provided samples from various godowns in Bihar, and others were received from Poona. Two rotting bacteria were found to be present invariably, and these appear to be normal in Indian soils. It was found that rotting could take place in presence of these bacteria either if the dry tubers suffered mechanical injury or if the uninjured tuber were kept under conditions in which its surface could remain moist for a few hours. Thus tubers stored in sand to keep out potato moth can be attacked if the rotting organisms are present, either through bruising due to careless handling or by reason of the sand not being perfectly dry, or by contact between a rotting

potato exuding moisture and a sound one; this last possibility necessitates frequent examination of stored tubers and picking out of rotten ones. Various antiseptics were tried on a small scale, of which copper sulphate proved the best; this will be tested along with other preventive measures in the ensuing season.

IV.—Programme of work for 1913-14.

A.—Biological aspects of soil under—

(1) Treatment with green manures.
(2) Rice cultivation.
(3) Sewage.
(4) Varying methods of tillage.

B.—Disease of indigo and solanaceous plants.

C.—General work on biology of soils and biological analysis.

D.—Training of students.

V.—Publications.

1. Rangpur Tobacco Wilt. C. M. Hutchinson. *Mem. Dept. of Agri. in India*, Bact. Ser., Vol. I, No. 2.
2. Drainage in Rice Soils. C. M. Hutchinson. *Agri. Journ. of India*, Vol. VIII, No. 1, January, 1913.

REPORT OF THE IMPERIAL COTTON SPECIALIST

(G. A. GAMMIE, F.L.S.)

I.—CHARGE AND TOURS.

I held charge of the appointment of Imperial Cotton Specialist throughout the year.

During the month of October 1912 I visited the North-West Frontier Province to discuss present and future operations in cotton cultivation with the Revenue Commissioner and the Superintendent of Farms. In November I attended the annual meeting of the District Agricultural Associations at Akola, where I met the Director and Deputy Director of Agriculture of the Central Provinces and then went on to Nagpur to confer with the Economic Botanist regarding his work on the improvement of his provincial cottons. In December I accompanied the Director and Deputy Director of Agriculture, Bombay, on a tour to all the experimental stations in Guzerat where we had ample opportunities of discussing matters on the ground greatly to our mutual benefit and understanding. In March I was on tour with the Director and Assistant Deputy Director of Agriculture in the Southern Mahratta Country and here again we had an opportunity of settling many points of interest in the fields. In April and May I was on tour in Guzerat with the Deputy Director of Agriculture. The intervening periods throughout the year were spent at head-quarters, supervising my own experimental station, arranging for the distribution of seeds required by many correspondents and also for the valuation of samples of cottons received from all parts of India.

II.—COTTON IN THE PROVINCES.

(*a*) *North-West Frontier Province.*—The following are my notes drawn up after a visit to this province. The

local variety of cotton is so productive and in every way so suitable to this province that I would not suggest replacing it by any other variety—either Indian or foreign. It is a mixture of varieties of the *neglectum* type and we agreed that the plants with narrow lobed leaves and pendulous lint should be selected and of these the best plant should be taken as the parent of the future stock. The red flowered cottons (*Multan*) may prove to be remunerative if they ripen in time, but, as this is doubtful, I should emphasize the necessity of the Department confining its trials to one type of plant. The value of this advice will be fully appreciated when seed in sufficient quantities is available for distribution. Then there is only one sort to deal with and mistakes and mixtures cannot possibly creep into the work.

The American cottons, as plants, are well grown but will not ripen their bolls. So far as we can at present judge, there are no great possibilities for exotic cottons in this tract, but there need be no discouragement on this score as the local product is quite satisfactory.

(*b*) *Punjab.*—Samples of 22 varieties were submitted to Messrs. Tata, Sons & Co., Bombay, for valuation and I append a copy of their report. These cottons have been grown on the Lyallpur Farm for several years and it is now time that some action should be taken in the selection and multiplication of the most promising for distribution to cultivators.

Valuation furnished by Messrs. Tata, Sons & Co., Bombay, on the 22 samples of cotton grown on Lyallpur Farm, on 15th May 1913.

Serial No.	Sample No.	Remarks.
1	7F	This cotton equals Middling American in colour, staple and strength, only it is slightly coarse to the feel. It can spin 40s. We value it at Rs. 350 per candy, say the price of Middling American cotton laid down in Bombay.
2	70F	Slightly shorter than No. 1 in length of fibre; in all other respects it is equal to the above. It can spin 30s—32s. Value Rs. 335.

Valuation furnished by Messrs. Tata, Sons & Co., Bombay, on the 22 samples of cotton grown on Lyallpur Farm, on 15th May 1913—contd.

Serial No.	Sample No.	Remarks.
3	72F	This is really an excellent cotton of a quality superior to Middling American. It can easily spin 50^s and our valuation is Rs. 400 per candy.
4	110F	This cotton is hardly superior in spinning quality to Fine Surats. The fibre is weaker than No. 2 and cannot spin over 22^s. Value Rs. 350.
5	111F	It resembles No. 1 in all respects, only the fibre is slightly stronger. It can easily spin 40^s. For strength of staple we value it Rs. 10 over the price of No. 1, say Rs. 360.
6	126F	This cotton resembles Fine Surats in its spinning quality. It is stronger in fibre than No. 4 and can spin 24^s. Value Rs. 325.
7	161F	It is slightly superior to No. 1 and can easily spin 40^s. We value it at Rs. 360 per candy.
8	168F	It is the exact counterpart of No. 4. Will spin 22^s. Value Rs. 320 per candy.
9	179F	This cotton lacks in body and has a different appearance than any of the above. It has, however, a soft feel though the fibre is of variable strength. On the whole it can spin 24^s and may be valued at Rs. 325 per candy.
10	199F	Equals No. 2 in all respects. Can spin 30^s—32^s. Value Rs. 335.
11	112F	Same as above. Will spin 30^s—32^s. Value Rs. 335.
12	211F	Equal to No. 6 in all respects. Will spin 24^s. Value Rs. 325.
13	226F	It is equal to ordinary Fine Broach, only it is superior in colour. It will spin up to 20^s. Value Rs. 295—Rs. 3 being added to the price of Broach for colour.
14	232F	Same as above. Will spin up to 20^s. Value Rs. 295.
15	233F	Equal to No. 2. Will spin 30^s—32^s. Value Rs. 335.
16	275F	Equal to No. 1. Can spin 40^s. Value Rs. 350.
17	280F	This is an excellent cotton equal to No. 3. Will spin 50^s. Value Rs. 410. We have added Rs. 10 to the value as we find that it is all round slightly better than No. 3.
18	281F	Equal to No. 1. Will spin 40^s. Value Rs. 350.
19	282F	Equal to No. 3. It is an excellent cotton. Will spin 50^s. Value Rs. 400.
20	266F	Equal to Surats in spinning quality. It is like No. 6. Will spin 24^s. Value Rs. 325.

Valuation furnished by Messrs. Tata, Sons & Co., Bombay, on the 22 samples of cotton grown on Lyallpur Farm, on 15th May 1913—concld.

Serial No.	Sample No.	Remarks.
21	..	*Deshi cotton, zamindari sample*, has all the characteristics of Sind Punjab cotton. It can spin up to 10ˢ and we value it at same price as Fine Sind Punjab Ginned, namely, Rs. 245.
22	..	*American cotton, zamindari sample*, shows good deal of variation in the length as well as the strength of the fibre. It seems that proper attention was not paid to this cotton on the zamindari land, hence the deterioration. We pull out a sample from a handful of this sample which can easily spin 24ˢ while another handful from the same sample gives a staple which can hardly spin 20ˢ. We therefore conclude that this "Mixed Staple" will not spin beyond 20ˢ and we value it at Rs. 315, say, Rs. 5 lower than our quotation of Surats.

Basis of prices on 13th May 1913 :—

		Rs.	
Middling American	.	350	per candy of 784 lbs.
Good Tinnevelly	.	330	,, ,, ,, ,,
Fine Surat	. .	320	,, ,, ,, ,,
,, Broach	. .	292	,, ,, ,, ,,

In forwarding this report I added the following remarks :—

"These cottons have now been successfully grown on the Botanical Experimental Farm for the past five years so that their suitability for your conditions has been abundantly established. From a practical point of view the distribution of the seed and subsequent supervision of the product of 20 selections is not possible and it would be as well to determine how few of these should be ultimately maintained.

Variety.	Remarks.
7F	Last year was compared with and valued equal to the best Surat cotton, or Rs. 45 per candy less than Good Middling American. This year it is valued as equal to Middling American laid down in Bombay at Rs. 350 compared on the same day with Good Tinnevelly, Rs. 330 ; Fine Surat, Rs. 320 ; and Fine Broach, Rs. 292.

Variety.	Remarks.
70F	Last year this was compared with the best Broach and valued at Rs. 5 more ; this year it is reported to be worth Rs. 335 or Rs. 15 less than 7F.
72F	Last year was reported to have a characteristic and style of Best Surat, being slightly better than 7F in length of fibre, and it was valued at Rs. 5 higher than 7F, *i.e.*, Rs. 325 per candy. This year it is said to be an excellent cotton of a quality superior to Middling American and its valuation is Rs. 400 per candy.
110F	Last year this cotton was said to resemble the superior grade cottons grown in the Central Provinces such as Warora and Hinganghat on account of its being slightly dull in colour and was valued at Rs. 5 lower than Warora. This year the cotton is found to be hardly superior in spinning quality to Fine Surats and is valued at Rs. 320 (Rs. 350 in the report being an error).
111F	Last year was found to be equal to 7F. This year the same conclusions have been arrived at, but on account of the fibre being slightly stronger it is valued at Rs. 10 more.
112F	Last year was the same as No. 111F, but a shade shorter in the length of fibre, therefore valued at Rs. 5 less ; this year it equals No. 70F.
126F	Last year it was said to be midway between the best Broach and Surat and valued at Rs. 10 more than Fine Broach. This year reported to resemble Fine Surats in spinning quality and valued at Rs. 325.
161F	Last year was considered to be the best of its kind grown in Indian soil and acclimatized in India. Valued at Rs. 385 against Rs. 365 for Good Middling American. This year it has been reported to be slightly superior to 7F and valued at Rs. 360, Middling American being Rs. 350.
168F	Last year and this year also reported to be hardly superior to Fine Surats.
179F	Last year reported to be equal to Fully Good Middling American. This year found to be lacking in body and with fibre of variable strength. Something has evidently happened to this number and it should be discarded.
199F	Last year valued at Best Broach style of cotton. This year it is said to be equal to 70F. This could be thrown out.
211F	Equals No. 126F and need not be kept up.
226F	Last year reported to be of the style of inferior cottons of the Central Provinces. This year is said to be equal to Ordinary Fine Broach.
232F	Last year and this year also reported as equal to 226F.
233F	Last year reported to be equal to 226F and this year equal to No. 70F. There is some discrepancy which should be inquired into.
275F	Last year said to be Broach style of cotton ; this year is said to equal No. 7F.
280F	This year said to be equal to 72F or perhaps Rs. 10 better.
281F	Reported to be equal to No. 7F.
282F	Equal to No. 72F.
266F	Equal to No. 126F.

"*Basis of valuation* on 10th May 1912 :—

	Per candy of 784 lbs.
American Good Middling . . .	7½*d.* c.i.f.
	Rs.
" " " . . .	365 Net.
Fine Navasari	340
" Surat	320 "
" Broach	285
" Warora-Hinganghat (Central Provinces)	290 "
" Wardha	285 "
" Yeotmal (Berars)	280 "
Good Tinnevelly	320

"*Basis of valuation* on 13th May 1913 :—

	Per candy of 784 lbs.
Middling American	350
Good Tinnevelly	330
Fine Surat	320
" Broach	292

"Zamindari sample of *Deshi* cotton has all the characteristics of Sind Punjab cotton.

"American zamindari sample is reported to show good deal of variation in the length as well as the strength of fibre. It is valued at Rs. 5 lower than Surats.

"An analysis of the report of your samples brings to light the fact that Nos. 72F, 161F, 280F and 282F in point of quality are by far the most desirable and it is quite probable that no harm would be done if these are mixed and treated under one number. You will then have a cotton which would meet the requirements of manufacturers for a high grade class of cotton grown in India. The only important doubt which remains in regard to these is whether their production is on a par with the quality; but this is a point which you have no doubt worked out. If the production is really satisfactory, I would strongly recommend you to do as I have already suggested; mix these numbers already given, test them on a large field scale—and if the result is still satisfactory the seed could be produced on seed farms for distribution in large quantities to selected cultivators. If you wish to keep them up, a number of the inferior types in your list could also be

amalgamated; for instance, from the point of quality alone there is no particular reason for keeping separate Nos. 126, 168, 211, 266.

"You should bear in mind that, unless you distribute the seed of only one variety or type into each tract or district, you will soon receive complaints of mixed cotton from the traders and the cultivators will suffer."

(*c*) *United Provinces of Agra and Oudh.*—The following valuations of Messrs. Tata, Sons & Co., on samples from Mr. Burt, are interesting as they show the strong possibilities of ultimate success in the cultivation of American cottons in the United Provinces. Until we apply the crucial tests of acreage outturn, percentage of cotton to seed, and other factors to these varieties it is obviously unsafe to say whether all or any of them are really profitable to grow, and it is to be hoped that the United Provinces Department of Agriculture will soon furnish us with the required information. The experiments in progress on the indigenous varieties are identical with those we have carried out to a definite conclusion in Berar and Khandesh.

Valuation furnished by Messrs. Tata, Sons & Co., Bombay, on the four samples of cotton from Cawnpore, on 16th July 1913.

Serial No.	Remarks.
1	*Dharwar American.*—Dharwar American seed sown in Cawnpore soil shows marked improvement in staple, though the colour has deteriorated. We value it at Rs. 290, say Rs. 25 more than the price of Dharwar simply for its staple.
2	*Cawnpore American acclimatized.*—The above remarks apply to this sample too, only the staple is slightly shorter than that of No. 1. Value Rs. 285, Rs. 20 above the price of ordinary Sawginned Dharwar.
3	*Boyd.*—This cotton is equal in all respects to Middling American. We value it at $6\frac{3}{4}d.$ per lb. laid down in Bombay, the equivalent in rupees being Rs. 350 per candy, Bombay terms.
4	*Black Rattle.*—This is a specially long stapled American cotton, equal to $1\frac{1}{4}''$ Bender American in staple and to Good Middling in class. We value it fully $\frac{3}{4}d.$ higher than Middling. Taking Middling at $6\frac{3}{4}d.$ this cotton is fully worth $7\frac{1}{2}d.$ per lb., rupee equivalent being Rs. 400 per candy, Bombay terms.

Basis of value.—Fine Khandesh, Rs. 230; Good Sawginned Dharwar, Rs. 652; and Middling American, Rs. 350 per candy

(*d*) *Central Provinces.*—I have reported so often and so fully on the excellent work done in this province that I have now little further to say. The outturn of the hardy indigenous varieties is so satisfactory and the product meets the demand of its market so well that there is no incentive to push the claims of longer stapled cottons, more specially as the conditions of soil and climate do not by any means favour these. An experimental farm for their cultivation may, however, be established in Western Chhattisgarh where conditions seem more favourable to exotic varieties.

Valuation furnished by Messrs. Tata, Sons & Co., Bombay, on the 9 samples of cotton from the Akola Farm, on 8th January 1913.

Serial No.	Name of variety.	REMARKS.
1	Berar Jari .	Ordinary Akola type of cotton. It is slightly harsh in feel. Value Rs. 318.
2	Rosea No. 1 .	Slightly superior to No. 1 in staple. Value Rs. 322.
3	Cutchica No. 1	Equal to No. 1. Value Rs. 318.
4	Vera . .	It is better than No. 2, both in feel and length of staple. Value Rs. 325.
5	Malvensis .	Midway between Nos. 2 and 4. Value Rs. 323.
6	Bani No. 3 .	It has all the characteristics of stapled Berars cotton. It is silky and has a long, strong, even fibre. Value Rs. 355.
7	Saugor Jari .	A short stapled Oomra equalling Dhamangaum cotton in style and colour, but the staple is shorter. With Dhamangaum at Rs. 330 we value this at Rs. 325.
8	Bhuri I . .	A long stapled cotton equal to No. 6, but slightly weaker in fibre. Value Rs. 345.
9	Bhuri II . .	Same as No. 8, but the fibre is more weak. Value Rs. 340.

N.B.—We have compared Nos. 8 and 9 with a sample of Cambodia cotton which we have purchased lately at Rs. 325, and we have based our valuation of these two samples on this comparison.

Basis.—F. Akola good at Rs. 320 per candy.

Some of the cotton varieties from the Northern Division of the Central Provinces, already alluded to in previous

reports, have again been reported on from samples sent by Mr. G. Evans, the Deputy Director.

The following are Messrs. Tata's valuations; 10th April 1913 :—

Serial No.	Name of variety.	REMARKS.
8	Saugor Jari (white flowered).	It is softer in feel than Khandesh, but inferior in staple. Value Rs. 268. (Basis Fine Khandesh, Rs. 272.)
9	Saugor Jari (yellow flowered).	Better in staple than No. 8, and we value it same as Fine Khandesh, *viz.*, Rs. 272 per candy.
10	Chhapara .	This sample may be classed as between Nos. 8 and 9. Value Rs. 270.
11 to 18	..	These 8 samples may be classed as Khandesh cotton. Nos. 11 and 12 are inferior in class and we value them at Rs. 265.
		Nos. 13, 15, 17 and 18 are worth Rs. 270 per candy. Nos. 14 and 16 show improvement in staple and we value them at Rs. 275 per candy. (Basis Fine Khandesh, Rs. 272.)

Nos. 8 and 9, Saugor *Jari*, white and yellow flowered respectively, again show the superiority of the staple from yellow flowered plants.

No. 10 is another local form discovered by Mr. Evans and its value lies midway between that of Nos. 8 and 9.

(*e*) *Madras*.—The following valuations of samples from the Nandyal and Hagari Experimental Stations show very graphically the rapid deterioration which takes place even in Indian cottons when their environment is altered. The necessity for a continuous importation of the seeds of such cottons is clearly demonstrated.

Valuations furnished by Messrs. Tata, Sons & Co., Bombay, on 21st September 1912.

Serial No.	Name of variety.	REMARKS.
1	Northern .	Shows no improvement in Nandyal soil. It looks like Kumpta, but being picked from selected plants, the fibre is longer than that of Kumpta. With Kumpta at Rs. 290 we value this cotton at Rs. 310.

Valuations furnished by Messrs. Tata, Sons & Co., Bombay, on 21st September 1912—contd.

Serial No.	Name of variety.	REMARKS.
2 to 9	Northern .	These are from the general crops and are very much alike except Nos. 2 and 6, which show a slight falling off in fibre. All are inferior to No. 1 in staple. Value Rs. 300.
10	Cambodia .	Grown at Cumbum, the cotton has much deteriorated both in colour and staple. The fibre is variable. We compare it with Westerns, and Good Westerns at Rs. 265. We value the sample at Rs. 260.
11	Do. .	Grown at Samalkot, it resembles Kumpta and find it equal to No. 1, only slightly inferior in colour. Value Rs. 305.
12 to 18	Selected . .	They equal the best class of Westerns. No. 12 has a slightly reddish tint, but is better in staple. Nos. 17 and 18 are slightly inferior in staple. With Westerns at Rs. 265, we value No. 12 at Rs. 275, Nos. 13 to 16 at Rs. 270, and Nos. 17 and 18 at Rs. 265.
19	Broach . .	Grown on Bellary soil, it has deteriorated and has adapted itself to the characteristic of the soil and has changed into Westerns. We value it at Rs. 270, say Rs. 5 better than ordinary Westerns.
20 and 21	Lalio and Kanvi	Grown on Bellary soil, both have deteriorated and have taken the appearance of Westerns. We value them at the price of Westerns, say Rs. 265.
22	Kumpta . .	The Bellary soil destroys the originality of an exotic and forces it to adapt itself to the soil and condition of the district. Kumpta, too, looks like Westerns, but the length of the Kumpta staple is maintained, hence we value it Rs. 10 better than Westerns, say Rs. 275.
23	Black-seed. Western.	The best indigenous cotton both in colour and length of fibre. Value Rs. 275.
24	Surat Broach .	Compared with No. 19 it has not deteriorated on Bellary soil as the seed was recently imported. Value Rs. 280.
25 and 26	Surat Kanvi and Lalio.	Compared with Nos. 20 and 21 they show less deterioration because the seeds are comparatively new. Value Rs. 270.
27	Broach Hagari	Compared with No. 24 it is slightly longer in length of fibre and we value it Rs. 5 higher, say Rs. 285.

In forwarding this report I ventured to suggest the following recommendations :—

Nandyal (1 to 9 of my numbers).—All are worth experimenting with on a large scale to test their actual production and ginning percentage. They are 10 to 20 per cent.

superior to Kumpta and 30 to 40 per cent. to Westerns, so that a decided step in improvement has already been taken Nos. 2, 6, 7 should be abandoned on account of their low percentage.

Hagari.—The value of the selections Nos. 12 to 16 is equal to that of the best class of Westerns. Those which show a further falling off in the ginning percentage this year should be given up. No. 17 might be given another chance, but a low price accompanied by a falling percentage is against 18.

Of No. 23, the black seeded cotton, Messrs. Tata, Sons say it is the best indigenous cotton (of these samples) both in colour and length of fibre. The ginning percentage is so low that the production would have to be high before the crop would pay to grow. As its quality is so highly spoken of, experiments with it should be persevered in as the percentage might improve.

Looking at the results of experiments conducted for several years with 3 types of Guzerat cottons, it is obvious that only Broach should be maintained and *Kanvi* and *Lalio* abandoned as they are of an inferior type. The result of the acclimatization of these is that they have adopted the characteristics of their new locality. Cotton from recently introduced seed is superior in price and ginning percentage, but without figures of production on a field scale it is impossible to say further than this.

But, granting that these are also superior, it would be the safest policy to bring in annually a large proportion—say 30 per cent.—of freshly introduced Broach seed into the cotton districts supplied by the seed farm at Hagari. We recommend that this seed should be obtained from the Experimental Farm at Surat.

The long growing season of the Guzerat varieties is perhaps the most vital objection to their introduction unless it be found possible to sow earlier as is done in the case of Broach cotton in the Dharwar District.

Koilpatti Farm.—The following are the valuations furnished by Messrs. Tata, Sons & Co. and the Chamber of Commerce, Bombay :—

Valuations.

Serial No.	Corresponding pedigree No. of the Koilpatti Farm during 1911-12.	Valuation by Messrs. Tata, Sons & Co., Bombay, on 19th December 1912.	Valuation by the Chamber of Commerce, Bombay, 8th February 1913.
		Karunganni A type—Single Plant Selection.	
1	24	Out of the 17 samples examined, we find Nos. 1, 11, 12, 13, 14 and 16 superior to the average type of F. G. F. Tinnevelly cotton, especially in length of staple. We value them Rs. 25 higher than the price of F. G. F. Tinnevelly. The rest of the samples show a slight superiority over the average F. G. F. Tinnevelly and we value them Rs. 10 higher.	Samples 11 and 12 considerably superior to any other. Value about Rs. 370 per candy of 784 lbs. (if available in quantities) with fully good fair Tinnevelly at Rs. 328. Nos. 13 and 14 second best, about Rs. 30 per 784 lbs. over fully good fair Tinnevelly. Nos. 1, 6 and 3. Value about Rs. 25 above fully good fair Tinnevelly. Nos. 2, 4, 5, 7, 8, 9 and 10. Value about Rs. 15 above fully good fair Tinnevelly. Nos. 15, 16 and 17 somewhat better in staple than the 2—10 series, but lower in class. Value about Rs. 10 above fully good fair Tinnevelly.
2	2		
3	1		
4	22		
5	17		
6	16		
7	15		
8	3		
9	6		
10	5		
11	8		
12	7		
13	14		
14	13		
15	12		
16	11		
17	10		
		Karunganni C type—Single Plant Selection.	
1	1	The colour of these samples is not so bright as that of A type. It shows a tinge of red and is creamy white. In appearance, feel and length of staple, it is equal to average F. G. F. Tinnevelly and we value it at the price of F. G. F. Tinnevelly cotton.	All samples have a reddish tinge. Nos. 2, 3 and 5 are somewhat better in staple than fully good fair Tinnevelly and perhaps slightly higher in value. Remaining samples are of about the same value as fully good fair Tinnevelly. All samples show a rather rough fibre.
2	2		
3	3		
4	5		
5	6		
6	7		
7	8		

Valuations—contd.

Serial No.	Corresponding pedigree No. of the Koilpatti Farm during 1911-12.	Valuation by Messrs. Tata, Sons & Co., Bombay, on 19th December 1912.	Valuation by the Chamber of Commerce, Bombay, 8th February 1913.
		Karunganni A-C types—Under Field Scale.	
1 2 3 4 5 6 7 8	1 F. P. 1 F. C. 1 F. C. 2 F. P. 2 F. C. 3 F. C. 3 F. P. 4 F. P.	Except Nos. 2 and 3, the other six samples are equal to ordinary F.G.F. Tinnevelly and we value them at the price of that cotton. Nos. 2 and 3 are decidedly better in appearance and length of staple and may be valued at Rs. 15 over the price of average F. G. F. Tinnevelly cotton.	We consider Nos. 6 and 8 the best on account of staple and value such cotton about Rs. 15 higher than fully good fair Tinnevelly. Nos. 4 and 7 we consider second best and about Rs. 10 higher than fully good fair Tinnevelly. Nos. 2, 3 and 5 are about equal to fully good fair Tinnevelly and No. 1 not up to fully good fair Tinnevelly.
		Basis.—F. G. F. Tinnevelly equal to Rs. 328 per candy of 784 lbs. laid down in Bombay.	*Basis.*—Fine Broach M. Gd. Rs. 330. Good Kumpta M. Gd. Rs. 335. Fine Navasari M. Gd. Rs. 360.

The work of this station is confined to the improvement of *Karunganni* which previously existed as a mixture in the fields with an inferior variety called *Uppam.* The valuations show that considerable progress has been made. My assistant, Mr. D. P. Mankad, who visited this locality last year, says that in Duraswamipura village, about 4 miles from the Koilpatti Farm, cultivators have been growing a *neglectum* mixture which they call *Pulichi paratti.* It is very important that the Department should take steps to check the introduction of such inferior varieties into this tract. The cultivators consider that the chief advantage of *Uppam* as compared with *Karunganni* lies in its shorter growing season, greater uniformity in ripening and superior hardiness.

Mr. Mankad has the following remarks on the cultivation of Cambodia cotton in Madras and these throw light on the causes which have led to the loss of reputation of this staple.

"During the past few years the cultivation of Cambodia in the Madras Presidency flourished remarkably well in garden soils commanded by well irrigation. The lands then were well ploughed and the cultivators paid special attention to its cultivation, including manuring, etc. Nowadays, however, any land is put out under this cotton and the methods of cultivation are rough and ready.

"All the fields under Cambodia were found to contain plants of *Uppam* and *Karunganni* types to a considerable extent. It is this admixture of inferior Madras cottons which has been noticed by the trade and has rendered Madras Cambodia unsaleable as high class cotton. This admixture not only tells upon the ginning percentage, but also on the quality of the fibre which is of vital importance in the trade.

"If some steps are not immediately taken to keep Cambodia *kapas* perfectly pure from local *kapas*, the present state of affairs will become still worse and this high grade cotton will fall permanently to the level of the local cottons in price."

(*f*) *Bombay.—Dharwar and Gadag Experimental Stations.*—I supplied the following report on my inspection of the stations :—

1. *Dharwar Farm, 14th March 1913.*

(1) There is a series of nine generations of Broach cotton showing a continuous deterioration to the Kumpta or local type. We agreed that the most practical method of maintaining the Broach character would be to renew the seed over the whole area once every three years.

(2) In *Kumpta* selections, quantity should not be lost sight of. A particularly good strain seems to be grown in the Sangli State and seed from this locality should be tried against that locally produced.

(3) *Cambodia* is not suitable for Dharwar conditions.

(4) Cross between *Kumpta* and *Comilla.*—If possible, plants with the *Comilla* leaf should be selected

so that, in the event of this strain coming into cultivation, mixtures with local Kumpta could be easily detected.

(5) The crosses between Soft Peruvian and Cambodia are promising. It is recommended that first selections should be reduced to one plant of each type.

(6) *Selected Kumpta.*—The seed of this has not yet been distributed. An attempt should be made to ascertain the actual opinion of the cultivators on its merits. If they consider it superior they should show their appreciation by offering a higher rate for the seed.

(7) *68E—Cambodia (plant 24, selection).*—The plants are vigorous but the bolls are small and do not open properly. It is recommended to continue the trial of this at Gadag where conditions are more suitable for Cambodia.

(8) The results of manurial experiments are still inconclusive.

(9) *Wind-break experiments.*—The *Shevri* will probably last for three or four years without renewal.

(10) There is general dissatisfaction regarding the quality of the introduced Navasari seed. It would be as well to depute a special officer to select seed on the spot, and the extra expense incurred could be met by a proportional enhancement in the price of seeds sold to cultivators. Your own suggestion to obtain seed of the superior strain distributed from Surat is probably a still better way out of the difficulty.

2. *Gadag Farm, 15th March 1913.*

(1) This farm might be restricted to trials with American types of cotton. One-half of the seed of each of the selected plants of Cambodia-Soft Peruvian should be tried here.

(2) It would simplify matters a great deal if the whole of the Cambodia was treated as being essentially one variety so that material for selection could be taken this year over the whole experimental area. This year's field results are rather disappointing and disquieting, but it is to be hoped that the cultivators will agree to give Cambodia a further trial and they ought to be warned that fraudulent mixing with Dharwar American will not go to serve their best interests in the market.

(3) There are two forms of Dharwar American mixed in the fields. I would suggest that one plot of each should be grown for comparison. I should also like to have a sample of the cotton from each for expert valuation this season. I am satisfied in my own mind that the alleged deterioration of Dharwar American is caused by the mixture of a superior and inferior type.

(4) Two of the crosses appear to be promising : Christopher and Christopher, and Culpepper and Christopher. The cottons of these should be submitted for valuation.

(5) The histories of the various cottons under trial in the Southern Mahratta Country have been carefully and intelligently kept up and they now possess a distinctly appreciable value.

Valuations furnished by Messrs. Tata, Sons & Co. on the samples from Dharwar and Gadag Farms, on the 29th May 1913.

Serial No.	Remarks.
	Samples of the Dharwar Farm, 1911-12 crop.
1	Kumpta ordinary. Value Rs. 290.
2	Kumpta Cross. This is an excellent cotton and shows much improvement in colour, staple and strength of fibre. In spinning quality we consider this cotton in no way inferior to indigenous Navasari cotton, only it lacks the soft silky feel and the creamy lustre of Navasari, hence we value it at Rs. 325. Of the five samples this is by far the best.

Valuations furnished by Messrs. Tata, Sons & Co. on the samples from Dharwar and Gadag Farms, on the 29th May 1913—contd.

Serial No.	Remarks.
3	Broach (new seed from Navasari). Grown on Dharwar Farm, this cotton has picked up some of the characteristics of the soil and climate. Being Navasari seed it is superior to Sawginned Dharwar and Kumpta, but it has deteriorated in the Dharwar soil from its original quality as grown in Navasari. This is owing, perhaps, to the high altitude and dry climate of Dharwar. We have marked that whenever Navasari has been removed further away from the sea it shows deterioration. We value this sample at Rs. 315.
4	Cambodia. Though superior to Kumpta and Dharwar it has lost its native lustre and strength of fibre and has deteriorated considerably on the Dharwar Farm. Value Rs. 300.
5	Kumpta × Ghogari. This cross is far superior to ordinary Kumpta, but it is inferior to No. 2 Cross. Value Rs. 315.
6	Kumpta ordinary. Slightly inferior to No. 1. Value Rs. 288.
7	Kumpta selected for quality. It shows improvement in colour over No. 6. Value Rs. 298.
8	Kumpta selected for quantity. It is inferior to ordinary Kumpta. Value Rs. 285.
9	Kumpta Cross. It shows improvement over Nos. 6, 7 and 8, but compared with No. 2, it shows considerable falling off in colour and length of staple. Value Rs. 305.
10	Broach old seed. It has lost all its characteristics of Broach and has deteriorated to the level of Kumpta, and we value it at Rs. 300. There can be no comparison between this and No. 3, as the latter retains its character of Broach cotton, while No. 10 has entirely lost it.
11	Kumpta × Ghogari. Compared with No. 5 it shows a slight falling off. This we attribute to No. 5, being crossed on the Surat and No. 11 on the Dharwar Farm. Value Rs. 310.
	Samples from Gadag Farm, 1911-12 crop.
12 to 17	Samples from Gadag Farm. These 6 samples are more or less alike and of the characteristic of Sawginned Dharwar cotton. No. 14 being machine ginned (not sawginned), shows better length of fibre over the rest which are sawginned. All the 6 samples show variations. We value Nos. 14 and 16 at Rs. 300 and the rest at Rs. 295.
18 and 19	Of the two, No. 18 is better in length of staple ; both the samples are superior to Kumpta or Dharwar ordinary. We value No. 18 at Rs. 305 and No. 19 at Rs. 295. (No. 18, Dharwar American type ; and No. 19, New Orleans type of 1912-13 crop.)

Basis of prices—

	Rs.
Good Sawginned Dharwar	288
Good Kumpta Ginned	290
Fine Broach Ginned	290
Good Northerns Ginned	295
Good Cambodia Ginned	320
Fine Navasari Ginned	340

In forwarding this report I submitted the following supplementary observations :—

Dharwar Farm.—We agreed that in the series of 9 generations of Broach cotton it showed a continuous deterioration to the Kumpta or the local type and that the most practical method of maintaining the Broach character would be to renew the seed over the whole area once every three years. Messrs. Tata state as follows regarding a sample of cotton grown from Broach new seed from Navasari :—

> " This cotton has picked up some of the characteristics of the soil and the climate. Being Navasari seed it is superior to sawginned Dharwar and Kumpta, but it has deteriorated in the Dharwar soil from its original quality as grown in Navasari. This is owing, perhaps, to the high altitude and dry climate of Dharwar. We have marked that whenever Navasari has been removed further away from the sea it shows deterioration. We value this sample at Rs. 315 against Navasari Rs. 340."

On a sample of cotton of Broach cotton from old seed (acclimatized seed) the remark is as follows :—

> " It has lost all its characteristics of Broach and has deteriorated to the level of Kumpta and we value it at Rs. 300. There can be no comparison between this and Broach cotton from new seed as the latter retains its character of Broach cotton, while the former has entirely lost it. This has been valued at Rs. 300 while Broach from new seed valued at Rs. 315 and original Navasari at Rs. 340."

In the Kumpta selections we agreed that quantity should not be lost sight of. The sample from a plot grown with this object in view was valued at Rs. 285 while a sample of ordinary Kumpta was valued at Rs. 288 and another at Rs. 290; while a sample of Kumpta selected for quality was valued at Rs. 298; while of the special selections the

Kumpta Cross No. 1339 from one plot was valued at Rs. 325 and from another at Rs. 305, the market price of the good Kumpta ginned of the day being Rs. 290.

Of the Kumpta Cross, which is the best cotton on the Dharwar Farm, Messrs. Tata have the following remarks :—

> "This is an excellent cotton and shows much improvement in colour, staple and strength of fibre. In spinning quality we consider this cotton in no way inferior to indigenous Navasari cotton; only it lacks the soft silky feel and the creamy lustre of Navasari, hence we value it at Rs. 325."

Of the second sample of the Kumpta Cross cotton they say that when compared with No. 1 it shows considerable falling off in colour and length of staple; the valuation is Rs. 305. The discrepancy in the quality is puzzling, but it may be capable of explanation.

Anyhow, valuations indicate that Kumpta Cross 1339 should be persevered with.

We decided that Cambodia is not suitable for Dharwar conditions and Messrs. Tata's opinion confirms this as they say :—

> "That though superior to Kumpta and Dharwar it has lost its native lustre and strength of fibre and has deteriorated considerably on the Dharwar Farm. It is valued at Rs. 300 against good Cambodia ginned Rs. 320."

Of the Kumpta and the Ghogari Crosses 1027A and 1364, Messrs. Tata say of the former that it is far superior to ordinary Kumpta but it is inferior to the Kumpta Cross 1339 and that the latter shows a slight falling off. The first is valued at Rs. 315 and the second at Rs. 310.

Gadag Farm.—We considered that it will simplify matters a great deal if the whole of Cambodia was treated as being essentially one variety, and this decision is con-

firmed by the remarks on the six samples made by Messrs. Tata :—

> "That they were all more or less alike and of the characteristics of sawginned Dharwar cotton The machine ginned sample shows better length of fibre over the rest which are saw-ginned. Two samples, Cambodia 102E and 67E, valued at Rs. 300 and the rest at Rs. 295 against Rs. 288 of good sawginned Dharwar and Rs. 320 good Cambodia ginned."

In conclusion, with reference to my statement that alleged deterioration of the Dharwar American cotton is caused by the mixture of an Upland and the New Orleans type of cotton, it seems that I am so far correct as Messrs. Tata value the former at Rs. 305 and the latter at Rs. 295. I hope that this year one full plot under each will be grown for comparison.

As regards the Cambodia cotton experiments which have been conducted in this tract, 3,500 acres were sown during the past year. Continuous rain during the seedling stage caused so much wilt that many plants died. The shoot borer would not allow the plants to grow until very late. The continuous east winds for six months (which is considered bad for cotton) caused many flower buds to drop and the soil moisture was quickly evaporated. The result of these adverse circumstances was that the yield was lowered by 40 per cent., that is, the yield should have been 350 to 375 lbs. per acre instead of about 210 lbs. The ginning percentage varied from 38 to 32·5 with a general average of 36·1.

The prices per *Naga* of 1,344 lbs. realized at the auction were Rs. 185 to Rs. 161, the quotations for Dharwar American and Kumpta on the same day being respectively Rs. 140 and Rs. 139 to Rs. 141.

Surat.—A set of samples from this station shows that the product has now become so uniform that there is only a difference of Rs. 13 per candy between the highest and lowest quotations.

Dohad.—Samples of *Bhuri* and Cambodia produced at this station were valued at Rs. 310, fine Broach of the day standing at Rs. 300. *Bhuri* yielded 1,104 lbs. seed cotton per acre, ginning percentage 32·8; Cambodia 876 lbs. per acre, ginning percentage 32·3. Early sown *Varhadi* yielded at the rate of 884 lbs. per acre, while the same late sown was cut off by frost. It will be seen, however, from the following remarks, that there is small prospect of extension of cotton cultivation in the Panch Mahals. The soils in which *Bhuri* and Cambodia were tried grow wheat in these parts. Panch Mahals does not grow much cotton, a portion from Derol to Pawagarh grows *Kanvi* and *Ghogari*, the latter predominating. Cottons come to maturity earlier in these parts owing to the stony nature of the soil. Kalol Taluka grows *Rozi* and *Kanvi* to a certain extent. Beyond this the cultivation of cotton practically ceases. It does not seem that the cultivation of cotton will spread, as the soil capable of producing cotton will yield two crops, namely, maize and gram, or groundnut and wheat.

Nadiad.—I submitted the following remarks on the samples sent by this station:—

Judging from the valuations of the cottons from Nadiad, Cambodia is easily first, but as this is a new introduction, some time must elapse before it can be confidently recommended for general cultivation under irrigation.

The claims of *Lalio* cotton indigenous to the tract should be carefully tested. It is highly probable that ultimately it would be found the most profitable to grow.

Bourbon is valued highly but its perennial nature is objectionable. Experiments made years ago certainly proved that it is not a reliable plant to depend upon. Mr. Spence's attempts at its cultivation on a large scale at Deesa and Jamnagar both signally failed and no one reports even moderate success with it. For all practical purposes the cotton experiments at Nadiad could be confined to trials with Cambodia and *Lalio*.

Valuations by Messrs. Tata, Sons & Co. on the six samples of Nadiad on 23rd June 1913.

Serial No.	Name of variety.	Remarks.
1	Cambodia .	Nadiad Farm appears to suit this cotton as all the characteristics of Cambodia are maintained. We value it at Rs. 320. We recommend that special attention should be given to its cultivation at Nadiad.
2	Bhuri . .	This cotton is after the style of Ghat Berars and we class it equal to Kirkeli. Value Rs. 300.
3	Lalio . .	The Nadiad soil suits the seed as the sample under inspection equals the best cotton grown in Bawla (Guzerat District). Value Rs. 290.
4	10 T. Bourbon	It is a very nice cotton, silky and long stapled, and is equal to some low grades of Egyptian cotton. We value it at Rs. 350.
5	Varhadi . .	This cotton has entirely changed its character and looks more like short staple Rajputana Bengal than like Khandesh. Value Rs. 250.
6	Comilla × Bani	This cross shows the roughness and feel of Comilla (Assam) combined with the staple of Bani. It can be compared to Fine Warora. Value Rs. 300.

Basis of value—

	Rs.
Low Egyptian	350
Fine Surat	330
Kirkeli	310
Fine Warora	300
,, Ghat (Chikli)	278
,, Bengal	245
,, Navasari	345
Cambodia	320
Fine Broach	305
,, Guzerat	290
,, Akola	268

At Bawla in the Ahmedabad District, Mr. Mankad reported as follows :—

" Four persons tested Cambodia on the following areas :—

Area in acres.	Total outturn in lbs.	Outturn per acre.	Valuation realised per 40 lbs. kapas.	REMARKS.
			Rs. A. P.	
0·24	680	1,133	6 6 0	Irrigated five times.
0·30	1,000	1,333	6 5 3	Irrigated three times.
1·0	800	800	6 4 0	Irrigated two times.
1·0	400	400	6 6 0	White-ants damaged crops. No watering given.

All the Cambodia was purchased by one man who gave ordinarily four annas more per maund over the local cotton *Lalio.*"

There is a tendency for the cultivators to extend the cultivation of Cambodia next year. I learn that cultivators are willing to pay high rates for the seed, as much as Rs. 5 for 40 lbs. seed. It was also said that some seed was sold at Rs. 8 a maund of 40 lbs.

With regard to the results of *Lalio*, it must be said that, under the same condition (irrigation), one acre and seven gunthas yielded 2,000 lbs. *kapas*, that is, 1,700 lbs. per acre. The possibilities of *Lalio* should be very carefully tested as present indications point to its being quite able to hold its own ground against Cambodia.

The cultivators at Bawla are, however, in favour of their local cotton—*Lalio*, and think that though the results are promising the new cotton, Cambodia, is a much more delicate variety than their local cotton. They are also aware of the fact that it would be susceptible to frost and insect pests.

To conclude with Guzerat, I quote the general remarks submitted to the Director.

" 1. *Surat.*—There are three strains maintained for seed distribution. The Syndicate have agreed to buy the produce of these at 5 per cent. over local prices and I am informed that private firms are independently offering 6

per cent. As this is the second season in which the improved cottons will be on the market it is gratifying to learn that the traders appreciate the value of the selections.

"2. *Broach.*—The tendency of the cultivators in this tract is to mix *Ghogari* with Broach in order to help out the ginning percentage of the latter. Some of the lighter soils might be devoted to the culture of pure *Ghogari*, but this point will be the subject of further enquiry. Broach cotton seed, obtained from Surat, was distributed by the local Agricultural Association. The members of this body have apparently not supervised the tests so closely as they require and they are only now invoking the aid of the Agricultural Department, as they foresee the difficulty of disposing of their produce on favourable terms without some support in the shape of an official guarantee. They may find a way out, but in the event of an expansion in their task of cotton seed distribution it would be as well to warn the Association to be guided by the advice of your Department. As you remarked, these Associations under proper control may become valuable agencies for the distribution and maintenance of selected crops. The Association ought soon to be strong enough to employ an expert staff to assist them in their operations. Wilt is said to be increasing in this district and is probably due to the continuous cropping of the land under cotton. I understand that the Imperial Mycologist has taken up the investigation of this disease.

"3. *Nadiad.*—Our long-cherished hope that some tree cottons could be profitably grown in the Kaira District has been dispelled.

Bourbon is too uncertain, as it is likely to do badly in wet years and, being a perennial crop, the land on which it grows, under the careless methods of the cultivators, becomes a jungle of weeds. It also acts as an agent in the propagation of boll worm. Cambodia and *Bhuri* both promise very well, if slight irrigation (which is available in many places) can be given them at the start. The claims of the local *Lalio* are strong and are being seriously considered.

"4. *Baroda.*—The experiments here are identical with those at Nadiad. There is a possibility that in this tract *Bhuri* can be grown as a dry crop. I pointed out on the spot that the Cambodia grown from Madras seed was contaminated with an admixture of *Uppam* and *Karunganni.* The plots at Nadiad had been of course purified by the Superintendent and I suggested that you instruct your Department in the Southern Mahratta Country to see that their fields were also purged of this annoying mixture.

"5. *Dohad.*—Cambodia, *Bhuri* and *Varhadi* (*roseum*) were doing exceedingly well, but it seems waste of time to distribute good cotton seed amongst such bad cultivators. However, the good example shown them at the Dohad Farm may show fruit in due time."

The Chief Karbhari, Rajkot State, sent in the following report on the crops resulting from 50 lbs. *Varhadi* and 20 lbs. Cambodia seed, which were sent to him for trial. The outturn of *Varhadi kapas* was $17\frac{1}{2}$ maunds in 2 *bighas* of the palace garden experimented upon, or in other words it was 21 maunds and 35 lbs. per acre (875 lbs. *kapas* per acre); whereas that of Cambodia *kapas* was $2\frac{1}{4}$ maunds in $\frac{1}{2}$ acre of it, *i.e.*, $4\frac{1}{2}$ maunds per acre, a maund being equal to 40 lbs.

The ginning percentage eventuated in 40 per cent. of *Varhadi* and 35 per cent. of Cambodia cotton.

The result is more in favour of *Varhadi* than Cambodia which does not, it seems, suit the soil. The *Varhadi* is being grown on a larger scale this season.

Valuation by Messrs. Tata, Sons & Co., Bombay, on the samples from Rajkot on 23rd June 1913.

Serial No.	Name of variety.	Remarks.
1	Varhadi . .	This cotton has preserved all its characteristics of Akola except the staple which shows deterioration. Value Rs. 260.
2	Cambodia .	The cotton has deteriorated all round and looks more like Ghat cotton (Chikli). Value Rs. 270.

Basis of valuation—

	Rs.
Fine Warora	300
,, Ghat (Chikli)	278
,, Akola	268
Mathio	250

Dhulia.—Messrs. Tata were good enough to supply the following valuations and remarks on the samples sent from this station (10th April 1913) :—

Serial No.	Name of variety.	Remarks.
1	Rosea . .	It has all the characteristics of Fine Khandesh cotton, only it is slightly better in staple than the usual run of Khandesh cotton for which we value it Rs. 8 higher than Fine Khandesh (basis Fine Khandesh, Rs. 272), say Rs. 280 per candy.
2	Cutchica	No improvement, practically Fine Khandesh. Value Rs. 272, being the basis of Fine Khandesh.
3	Vera . .	It has lost its Khandesh characteristics and has the colour, staple and feel of Bani Berars. Taking Rs. 320 as the basis of Bani Akola, we value it the same price, Rs. 320 per candy.
4	Malvensis .	It is like No. 1. The feel, however, is better, which advantage is counterbalanced by the staple being slightly inferior. We value it at Rs. 5 more than Fine Khandesh (basis Rs. 272), say Rs. 277 per candy.
5	Khandesh Jari	It is ordinary fully Good Khandesh cotton. Value Rs. 262 (same as fully Good Khandesh, basis of Rs. 262).
6	Bani . .	It is equal to No. 3 and of the same value, say Rs. 320 per candy.
7	Comilla . .	In the Khandesh soil and climate it has slightly lost its native harshness; in all other respects it remains Assam cotton. We value it at Rs. 275 per candy, say Rs. 15 better than Superfine Bengal (basis Superfine Bengal, Rs. 260).

Valuations.—All samples received were submitted to Messrs. Tata, Sons & Co., Bombay, for valuation, and cordial acknowledgment is due to them for their kindness and promptitude in giving opinions on cottons whenever submitted to them.

Samples of the Koilpatti Agricultural Station were reported upon by the Bombay Chamber of Commerce to whom thanks are also due.

III.—Programme of work for 1913-14.

(1) To visit and advise on points regarding cotton and its cultivation whenever requested to do so by Provincial Departments of Agriculture.

(2) By special invitation of the Departments of Agriculture of the United Provinces of Agra and Oudh, Bombay, and North-West Frontier Province to report on the work done in the way of cotton improvement in those provinces.

(3) The question of the distribution of seeds of promising varieties will be further discussed with the proper authorities in the United Provinces, Central Provinces, Bombay and the Punjab.

(4) The study of the behaviour of *Bhuri* and Cambodia and other such cottons in non-cotton-producing tracts will be continued.

(5) An enquiry on the manurial requirement of cotton will be continued.

(6) Researches on the botany of cotton will be continued.

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
8, HASTINGS STREET

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1913-14.

REPORT OF THE DIRECTOR.

(BERNARD COVENTRY, C.I.E.)

I.—CHARGE AND STAFF.

Charge.—Mr. J. Mackenna, M.A., I.C.S., held charge of the office of Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, till my return from leave on the 23rd February 1914, when I resumed charge of the post.

Mr. A. C. Dobbs held the post of Assistant to the Agricultural Adviser to the Government of India till 28th April 1914, when he was appointed to act as Imperial Agriculturist and Mr. M. Wynne Sayer, B.A., who joined the Department on the 20th March 1914, was appointed to officiate for Mr. Dobbs.

Staff.—The Chemical Section remained in charge of Dr. J. W. Leather, V.D., Ph.D., F.I.C., throughout the year.

Mr. H. E. Annett, B.Sc., F.C.S., F.I.C., Supernumerary Agricultural Chemist, returned from study leave on 28th November 1913, and was appointed Agricultural Chemist to the Government of Bengal on 1st January 1914. Mr. Jatindranath Sen, M.A., F.C.S., First Assistant in the Chemical Section, was appointed Supernumerary Agricultural Chemist on the 9th February 1914.

Mr. A. Howard, M.A., A.R.C.S., F.L.S., Imperial Economic Botanist, and Mrs. Howard, M.A., his Personal Assistant, returned from leave on 19th October 1913. As

in previous years Mr. and Mrs. Howard proceeded to Quetta in May 1914, and will stay there for five months for work in connection with the development of the fruit industry in Baluchistan. During the year under report Mr. Howard was appointed a Companion of the Most Eminent Order of the Indian Empire.

The Mycological Section was in charge of Dr. E. J. Butler, M.B., F.L.S., till the 28th March 1914, when he proceeded on nine months' combined leave.

Mr. F. J. F. Shaw, B.Sc., A.R.C.S., F.L.S., on the termination of his appointment as Officiating Government Mycologist, Madras, resumed his duties at Pusa as Supernumerary Mycologist on the 5th November 1913. He has been appointed to officiate as Imperial Mycologist during Dr. Butler's absence on leave.

Mr. T. Bainbrigge Fletcher, R.N., F.E.S., F.Z.S., joined the post of Imperial Entomologist on 1st December 1913. Previous to his appointment Mr. A. J. Grove, M.Sc., Supernumerary Entomologist, held charge of the Entomological Section. Mr. Grove has been deputed to the Punjab since 28th January 1914, to carry out work on grain pests and cotton bollworm.

Mr. F. M. Howlett, B.A., F.E.S., remained in charge of the Pathological Entomological Section throughout the year.

The Bacteriological Section was in charge of Mr. C. M. Hutchinson, B.A., during the whole year, except for a short period of two weeks from 24th February 1914, when he was on privilege leave and Mr. J. H. Walton, B.A., B.Sc., Supernumerary Agricultural Bacteriologist, officiated for him.

The Agricultural Section was in charge of Mr. S. Milligan, M.A., B.Sc., till 28th April 1914, when he proceeded on one year's combined leave and Mr. A. C. Dobbs took over charge from him.

The number of Supernumerary Agricultural appointments was reduced from three to two during the year under report. Mr. N. S. McGowan, Dip. in Agri. (Cantab.), and Mr. T. Gilbert, B.A., Dip. in Agri. (Cantab.), have been

appointed Deputy Directors of Agriculture in Bihar and Orissa and Bombay respectively. The two Supernumerary posts are now held by Mr. G. D. Mehta, L.Ag., B.A., N.D.A., N.D.D., who has been posted to Madras for training, and Mr. M. Wynne Sayer, B.A., who joined the Department on 20th March 1914.

II.—Work of the Institute.

Scientific Work.—An account of the scientific work of the Institute during the year is given in the reports of the several sections.

Training.—The training of students in post-graduate courses was continued and short courses were also given in Cattle management and Sericulture.

Four students were under training in Agricultural Chemistry during the year under report. The two students referred to in the last year's report, *viz.*, a private student from Madras and a Government Stipendiary from the Travancore State, completed their training. A private student who was studying for the D.Sc. degree of the Allahabad University worked on a piece of research for eight months in the Chemical Laboratory. A student deputed by the Department of Agriculture, Central Provinces, for training in Agricultural Bacteriology was given a preliminary course of training in Agricultural Chemistry.

In the Entomological Section the student deputed by the Department of Agriculture, Travancore, and the student deputed by the Assam Department of Agriculture referred to in the last year's report completed their training in General Entomology during the year under report.

In the Bacteriological Section the probationary research assistant under the Agricultural Chemist to the Punjab Government who was deputed to this Institute for training continued his course in Agricultural Bacteriology during the year.

In the Agricultural Section a graduate of the Sabour Agricultural College deputed by the Bengal Department of Agriculture is undergoing training in General Agriculture.

Besides the regular students mentioned above, the following officers worked in the Mycological Laboratory during the year :—

Mr. A. C. Tunstall, Mycologist to the Indian Tea Association, for about a week, in September 1913.

Mr. G. H. Alington, I.F.S., Assistant to the Forest Botanist, in January 1914, in connection with tree diseases.

Mr. B. L. Gupta, B.Sc., Professor of Biology in the Reid Christian College, Lucknow, attended the Laboratory during May and June 1914, and received a course of lectures and practical work on the morphology of fungi.

During the year under report, seven students attended the short courses—one in "Cattle Management" and six in "Sericulture." Besides the regular students, three visitors were given practical instruction in sericulture and silk-dyeing.

III.—Publications.

The Agricultural Journal, Scientific Memoirs and Bulletins continued to be issued during the year. With a view to keep down the free distribution list and also to encourage Agricultural Associations, Co-operative Societies, students of Agricultural Colleges and Assistants in the Agricultural Departments, specially reduced rates of subscription for the Journal and Memoirs and Bulletins were sanctioned during the year. This has led to a substantial increase in the number of subscribers. With a view to economy steps were taken to supply persons and institutions on the free distribution list with reprints of articles on the special branches of agriculture and its allied sciences in which they are interested in lieu of the Journal. Arrangements were also made during the year for making the Department's publications available for sale at principal centres in various parts of the country.

The Department published during the year 16 Memoirs and 7 Bulletins. In the Veterinary Series of Memoirs

started in April 1912 no less than 8 papers have been published during the course of two years and the number promises to increase in the near future. As regards other series of memoirs a good number of papers were published in the Botanical and Chemical Series to which the Provincial Departments have also contributed.

There is a steady increasing demand from the Indian public for Bulletins as they are mostly of practical interest. As a result Bulletin Nos. 28 and 29 on Lac and Eri silk culture have been reprinted and the Government of India have authorised the Agricultural Adviser to increase in future to 2,000 copies bulletins for which there is likely to be a good demand.

The grant for publications as at present sanctioned is Rs. 29,000. During the last two years greatest economy had to be exercised to keep the expenditure within the sanctioned grant. The rates both for letter-press printing and reproduction of illustrations have been recently revised. Papers received are also carefully scrutinised and all illustrations not absolutely required are eliminated. But as the investigation of problems is yearly on the increase the volume of matter offered for publication is anticipated to become larger each year and it will soon be necessary to ask for a further addition to the grant.

IV.—General Administration.

Buildings and Works.—During the year under report the Government of India sanctioned the construction of eight additional quarters for the subordinate staff of the Institute. The extension of the Director's office building referred to in the last year's report was completed during the year. Proposals have been submitted to Government for the installation of electric lights and fans in the European bungalows and the Guest House at Pusa, and for the addition of a Female Ward to the Pusa Hospital.

Library.—The third edition of the catalogue of the library is in the press and will shortly be out. During the year under report over 500 volumes have been added by purchase besides several foreign bulletins, memoirs, reports,

etc., which are received in exchange from different parts of the world.

Pusa Middle English School.—The Pusa Middle English School which was established in 1912 is becoming popular. It has four English and four Vernacular classes and the total number of boys on the roll is 93 out of which 53 belong to the Estate and the remaining 40 come from the neighbouring villages. The school is located temporarily in the Students' Hostel until the completion of the school building which is under construction. Proposals for raising the present school to the status of a High School and also for the establishment of a Girls' School at Pusa are under the consideration of the Local Government.

General Health of the Station.—The general health of the station during the year under report was on the whole very good. Relief was afforded to 9,226 cases, of which 8,999 were treated in the out-patients' department and 227 admitted as in-door patients. One hundred and two cases amongst European officers and families were attended to. The daily average number of patients treated was 64·05 out-door, and 10·69 in-door.

Four deaths occurred in hospital, one from Gangrene-foot, one from Malarial Cachexia, one from Cirrhosis Liver and one from Suppurating Tonsilitis.

The number of Estate cases treated for Malarial Fever was small when compared with the admissions from the neighbouring villages. This was probably due to the Estate people willingly taking the quinine which was issued prophylactically towards the close of the monsoon. An epidemic of cholera which broke out in the villages in the immediate vicinity of Pusa, during the months of April, May and June, threatened to be a source of grave danger. Immediate and successful measures were taken to prevent it entering the Estate. Chief of these was keeping of the water supply pure by disinfecting and cleaning the wells. The epidemic was thus kept out of the Estate limits.

Two hundred and five surgical operations were performed of which nineteen were major, and one hundred and eighty-six minor.

Nine primary vaccinations and three re-vaccinations were performed during the early part of the year.

V.—Accounts.

The total expenditure during the financial year 1913-14 was Rs. 4,72,471 as under :—

	Rs.
Office of the Agricultural Adviser to the Government of India and Director of the Institute	2,14,158
Chemical Section	38,455
Mycological Section	37,388
Entomological Section	33,942
Pathological Entomological Section	26,749
Botanical Section	27,854
Bacteriological Section	29,171
Agricultural Section	64,754
	4,72,471

The budget of the Agricultural Adviser for the year under report included a portion of the grant of Rs. 1,10,000 referred to in previous year's report for meeting the expenditure in connection with the engagement of Mr. W. Hulme as Sugar Engineer in the United Provinces for the development of the Indian Sugar Industry. The engagement of Mr. Hulme was sanctioned in the first instance, for three years from 1911-12. It has been decided to retain his services for a further period of two seasons and the expenditure during the current year will be met from the saving in the grant of Rs. 1,10,000 made for the purpose.

A sum of Rs. 15,000 was provided in the budget for payment to the Indian Tea Association as a grant-in-aid.

Out of the sum of Rs. 60,000 allotted during the year ending 31st March 1914, by the Government of India, for improvements connected with the Pusa Institute, Rs. 14,254 were transferred to the Public Works Department Budget for meeting the cost of extension of the Pusa Library and Rs. 25,000 paid towards purchase of steam cultivating machinery for the Pusa Farm. The balance was spent on

testing the milling and baking qualities of wheat, the bacteriological investigation of rice, the demonstration of improved methods of refining saltpetre, experiments with cotton and plant breeding by the Imperial Cotton Specialist, construction of a Potculture house for the Imperial Mycologist, an additional Laboratory for the Imperial Pathological Entomologist and the improvement of the drainage of the low-lying portions of the Pusa Estate.

The gross receipts during the year from the sale of farm produce, milk, publications of this Department and other articles, amounted to Rs. 22,157 as against Rs. 14,663 of the preceding year.

VI.—Visitors.

In response to the invitation of Mr. J. Mackenna, Lord Islington, Sir Valentine Chirol, Sir Theodore Morison, Messrs. Sly, Scott and Fisher of the Royal Commission on Public Services in India visited the Institute on the 17th January 1914.

During the year under report the Hon'ble Sir Robert Carlyle, K.C.S.I., C.I.E., I.C.S., Member-in-charge of the Department of Revenue and Agriculture, Government of India, the Hon'ble Sir Edward Maclagan, K.C.I.E., C.S.I., I.C.S., Officiating Revenue Member, the Hon'ble Mr. L. J. Kershaw, C.I.E., I.C.S., Secretary to the Government of India, Department of Revenue and Agriculture, Colonel E. H. Hazelton, F.R.C.V.S., A.V.S., Principal Veterinary Officer in India, Mr. M. J. Cogswell, Controller of Printing, Stationery and Stamps, Professor Wyndham R. Dunstan, M.A., LL.D., F.R.S., Director, Imperial Institute, London, Professor Brück of Griessen University, Germany, Mr. M. A. Yamada of the Agricultural Experiment Station, Formosa, Chev. Dr. G. Gorio, Consul for Italy, Bombay, and many others visited the Institute.

REPORT OF THE IMPERIAL AGRICULTURIST

(A. C. DOBBS, B.A.)

I.—ADMINISTRATION AND TOURS.

Charge.—Mr. Milligan held charge of the Pusa Farm for the first ten months of the period under review; he went home on long leave at the end of April, after which the writer officiated for him.

The number of Supernumerary Agricultural appointments was reduced from three to two during the year under report. Messrs. Gilbert and McGowan vacated their posts on the supernumerary establishment, on the creation of new appointments on the regular cadre in Bombay and Bihar, and one of the resulting vacancies was filled by the appointment of Mr. M. Wynne Sayer who arrived in India at the end of March, and is now officiating as Assistant to the Agricultural Adviser.

The other post vacated was absorbed in one of the new posts on the regular cadre, while the second remaining Supernumerary appointment continues to be held by Mr. G. D. Mehta, now working in Madras.

Mr. Judah Hyam was in charge of the Breeding Herd throughout the year.

Mr. Mohomed Ikramuddin held the post of 1st Farm Overseer during the year, in addition to the duties of the 2nd Farm Overseer from 16th May 1913 to 4th November 1913.

Mr. Arjan Singh, Agricultural Assistant, Lyallpur Farm, was posted to the vacant post of 2nd Farm Overseer on the 5th November 1913.

Training.—The following students attended the courses :—

1. Mr. B. M. Valweker, from Mysore State, in cattle management, from 29th January 1914 to 4th April 1914.

2. Mr. Kali Prosanna Roy was sent by the Bengal Government for agricultural training at Pusa.

Tours.—Mr. Milligan visited Dacca and Sabour Farms with the Officiating Agricultural Adviser to the Government of India, in August; and Poona, Bombay, Ahmedabad and Umballa to see dairies in September 1913. He also attended the meetings of the Board of Agriculture at Coimbatore in December 1913 and gave evidence before the Public Services Commission on behalf of the Imperial Department of Agriculture, at Bombay during February 1914.

II.—Farm Cultivation.

Character of the season.—The rains began with 7 inches in May 1913. The monsoon was characterised by well distributed rainfall throughout, with very heavy falls in June and August. The paddy crop was considerably damaged by floods owing to the defective draining of the Estate. Three-fourths of an inch of rain in the middle of October and again in the middle of December, ensured heavy *rabi* crops, which, however, suffered severely from a similar fall accompanied by strong wind in the middle of February.

Crop Experiments.—The experiments mentioned in last year's report have been continued.

Cultivation.—A Fowler's double engine steam cultivation tackle was obtained in September 1913 with a disc plough, cultivator, harrow, and roller.

The object of this new departure was not only the study of the economics of steam cultivation, but also to enable the Agriculturist to deal more effectively with the labour difficulties incidental to the intensive cultivation, by means of hired labour, of so large an area as is necessary to support the Pusa herd of Montgomery Cattle.

The farm is not an ideal one for steam cultivation, being intersected by public roads which cut it up into irregularly-shaped fields, but by taking the whole available area, squaring up some of the fields, and abandoning odd corners, it will be possible to eliminate most of the land that cannot be

ploughed by steam tackle and yet to leave a sufficient area to employ the tackle to the limit of its capacity. There will still, however, be some waste incurred in moving over considerable distances from field to field.

III.—Live-stock and Poultry.

Breeding Herd.—As may be inferred from the reference above to the herd of Montgomery cows, this herd has become the pivot on which the policy of the farm turns.

Started originally with the idea of preserving and typing the Montgomery breed, and incidentally providing the officials collected at Pusa with a pure milk supply, the herd has grown with the expansion of the Institute and the growing demand for milk from the large number of inhabitants of the estate,—until it has taxed the capacity of the farm to provide sufficient fodder for both the working bullocks and for the breeding herd.

A partial solution has been found in the purchase of the steam tackle, and it is proposed at the same time to grade up the milk producing power of the herd by crossing the poorest milkers with an Ayrshire bull.

The product of this cross has been demonstrated by the Military Dairies in Northern India to be exceedingly useful, the heifers giving milk in amounts comparable with those given by Ayrshire cows, while the bullocks make excellent work cattle.

There will therefore be maintained at Pusa, henceforth, two herds; one of selected milkers of the Montgomery breed; the other a herd of cross-bred Ayrshire-Montgomery cattle which will, it is hoped, take its part in a comprehensive scheme for improving the dairy cattle of India by cross breeding.

Should a considerable development of one or both of these breeds be justified later on, it will be possible to increase considerably the number of breeding cattle at Pusa, owing to the economy of fodder effected by the use of the steam tackle instead of bullocks for cultivation.

Sheep.—The advantage of crossing Dumba rams with the local sheep for the production of mutton having been demonstrated, breeding for mutton has been given up, and an attempt is being made to improve the wool of the local sheep by crossing with Merinos, as mentioned in last year's report.

Poultry.—In view of the general interest now evinced in poultry keeping in the Provinces it has been decided to limit the functions of Pusa to the importation of pure bred birds to maintain the breeds kept on Provincial farms. The Assistant to the Agricultural Adviser to the Government of India is in touch with breeders at home and is prepared to give his advice or assistance to intending importers. No poultry are now kept at the Pusa Farm.

IV.—General.

All the available farm land has been brought under cultivation.

Manuring with superphosphate has become part of the routine practice of the farm as a result of the proof of the economic value of that manure in the experimental plots.

Considerably better crops have been obtained in recent years and with the high cultivation now rendered possible an economic necessity is beginning to appear of growing more valuable crops, or varieties with sufficient strength of root and stem to support a higher yield than any obtainable from the varieties now available.

V.—Programme of work for 1914-15.

The following are the lines of work in progress :—

Major investigations.

1. The economics of cultivation by steam and motor engines.

2. The puddling of rice land by the double engine system of steam cultivation.

3. The combination of irrigation and drainage in the growing of rice.

4. A study of inheritance of the more important characters of dairy cattle by crossing.

5. The building up of milk pedigree in cattle by selection.

Minor investigations.

6. The inheritance of wool characters in sheep.

7. Experimental tillage in the growing of maize and sugarcane.

8. Improvement of pastures.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(J. WALTER LEATHER, V.D., PH.D., F.I.C.)

I.—ADMINISTRATION AND TOURS.

Charge.—The section was in the charge of myself during the whole year.

Establishment.—Mr. H. E. Annett, Supernumerary Agricultural Chemist, returned from study leave on 28th November 1913 and was appointed Agricultural Chemist, Bengal, on 1st January 1914.

Mr. Jatindranath Sen, First Assistant in this section, was appointed Supernumerary Agricultural Chemist (probationary) on February 9th, 1914.

Mr. Jatindra Nath Mukerjee, Second Assistant, was appointed First Assistant on 9th February 1914.

Mr. A. V. Iyer, a former assistant of this section and latterly Assistant Agricultural Chemist, Sabour, was appointed Second Assistant on 2nd July 1914.

Babu Har Dyal Singh, a junior assistant, was transferred to the Bacteriological Section on 25th May 1914.

Babu Shasanka Bhushan Roy, L.Ag. (Sabour), was appointed (probationary) to the vacant assistantship on 23rd June 1914.

Tours.—The following tours were made by me :—

1. August 1913. To Meerut and Delhi to discuss the value of certain fodder grasses and grass lands with the Assistant Director of Grass Farms. To Roorkee where I discussed the construction of certain instruments with the Superintendent, Canal Foundry and Workshops. To Cawnpore where I examined the condition of certain lands which had been broken up with explosives.

2. October 1913. To Peshawar to inspect the sugar-beet crops and to arrange for the prospective tests of sugarcane and sugar-beet at Tarnab.
3. December 1913. To Coimbatore to attend the meeting of the Board of Agriculture.
4. January 1914. To Peshawar to inspect the work of the assistant who had been posted there to test sugarcane and beet.
5. March 1914. To Bareilly to discuss the practicability of the small factory for sugarcane and sugar-beet with the Sugar Engineer.
6. April and May 1914. To Peshawar, (*i*) to inspect the work on sugar-beet and to discuss the data with the Agricultural Officer; (*ii*) to take samples of soil from the Upper and Lower Swat River Canals. To Lyallpur to act as a member of the Board of Examiners at Agricultural College.
7. June 1914. To Peshawar on account of sugar-beet analyses.

II.—Education.

Four students have been under instruction during the year. One Government and one private student completed their full courses; one Government student has completed the course (one year) specially prescribed for him. One private student who was studying for the D.Sc. degree, Allahabad, worked here for eight months on a piece of research.

III.—Meteorology.

In addition to the usual data which are recorded daily on behalf of the Meteorological Department, records of (*a*) soil temperature, (*b*) drainage, and (*c*) pressure by means of a barograph have been maintained.

IV.—Soil Problems.

Drainage.—The records of drainage are maintained and it is probable that another collection of data will be published early next year.

Lime and Magnesia.—The relationship between the amount of gaseous carbonic acid in soils and the amounts of lime and magnesia in solution has been the subject of an investigation which has been conducted by Mr. Sen and myself. The first section of the work was published in 1909 and dealt with the relation between calcium carbonate and gaseous carbonic acid. The second section dealt with the corresponding relationship of magnesium carbonate and carbonic acid. Following this we ascertained the solubility of the two carbonates when present together and also of dolomite under like conditions. It then transpired that if magnesium carbonate is present in anything more than quite small quantities, calcium carbonate becomes practically insoluble. Dolomite was found to dissolve as a double salt in carbonic acid, but the maximum concentration which we could obtain was smaller than was anticipated from a consideration of the other work. The presence of either calcium carbonate or magnesium carbonate was found to protect dolomite from the action of carbonic acid. Magnesium carbonate protects it practically entirely, because it rapidly forms a solution of bicarbonate so concentrated that no appreciable amount of calcium carbonate can dissolve in it and hence the dolomite cannot dissolve. Calcium carbonate does not protect it quite so perfectly, but this salt rapidly forms, in contact with carbonic acid and water, a solution of bicarbonate so strong that little or no more calcium carbonate can dissolve in it and hence the dolomite can only dissolve to a limited degree.

This work has shown that no fertile soil can contain material proportions of magnesium carbonate, for if it did, the lime would become practically insoluble and the plant would die of lime starvation. This is probably the reason why in so many of the experiments which have been made in Europe and America on Loew's lime-magnesia ratio in

soils, the application of magnesite or magnesium carbonate has proved so harmful. The details of this investigation have been published as *Memoirs of the Department of Agriculture in India, Chemical Series*, Vol. III, No. 8.

Swat River Canals land.—A number of samples of soil from the land which has been irrigated by the Lower Swat River Canal and from the land which will come under the Upper Swat River Canal were taken during April and May by the Superintending Engineer and myself from places, the exact position of which has been registered with reference to certain bench-marks on the canals. This latter was done in order that samples may, if desired, be taken from the same places on a future occasion. The original object of taking the samples was to supply information respecting the soil to an engineer in England who has asked for information respecting the chemical composition of these soils. In addition to this, however, Mr. A. J. Wadley, the Superintending Engineer, was himself interested in the subject, and the series of samples was for this reason somewhat increased.

The lands which are commanded by these two canals are very similar, in that they consist of the alluvium which lies at the foot of the Himalayas in this part of India, and although close to the low hills, and indeed some of the isolated outcrops occur in the alluvium, it consists almost entirely of fine alluvium without stones. The land which will come under the Upper Swat River Canal lies close to the hills; that which has been irrigated by the Lower Swat River Canal lies further south. Only certain items in the composition of the soils were determined, those indeed which are most likely to indicate their agricultural value or defects. In respect of *calcium carbonate*, this constituent varies within wide limits, being as high as 10 per cent. or more in four samples and as low as ·04 per cent. in three. Usually there is a sufficiency for agricultural purposes, but when the proportion falls as low as ·04 per cent. it will probably pay to add lime. Of *phosphate* in a readily assimilable condition there is in some cases a deficiency.

and it is very probable that if artificial manures are ever used in India generally, it will pay to use superphosphate on some of these lands. Of *potash* there is an abundance, whilst of *organic nitrogenous matter* there is the same deficiency that is so common to Indian soils. Respecting their physical condition they are generally good.

A question was incidentally raised as to whether the lands under the Lower Swat River Canal had deteriorated at all. So far as one can tell from these samples, and they were taken from widely separated places, there was nothing to indicate that any depreciation has occurred, and in fact generally these were richer and better than those from the other area.

The Percolation Test for soils.—Some years ago I devised a method for testing the permeability of soils to water. Its immediate object was then the differentiation of certain *usar* soils of the United Provinces.

During the past year a long series of tests with it have been applied to good agricultural soils in order to ascertain its more general applicability. The test appears to make a sharp differentiation between soils which are physically good or bad respectively. The information which has been gathered on the subject will be submitted for publication shortly.

V.—Saltpetre.

The experiments on improvements in the saltpetre refining process advanced a stage this year. A filter press was obtained from Europe which has shown itself able to deal with the mud very expeditiously. The pumps supplied with the press were, however, defective and another mode of applying the liquid to the press will now be tried

In the meantime the solubility relations of the chief salts which are present have been worked out by Babu Jatindra Nath Mukerjee and myself and published as *Memoirs of the Department of Agriculture in India. Chemical Series*, Vol. III, No. 7.

VI.—Sugar.

The work of this section on sugar has been confined to a series of investigations at Tarnab Farm, North-West Frontier Province.

Reference was made in my last Annual Report to the tests of the sugar-beets which Mr. Robertson Brown had grown, and to the fact that the quality of the roots had proved to be very good.

It has been evident throughout in respect to this crop, that the subject must be considered from the manufacturing standpoint, because of the fact that marketable sugar could only be produced from the beet root in a factory. This alone necessitates a regular supply of roots over at least several months because otherwise a factory could not hope to pay. It followed therefore that the next desirable step in the work was to ascertain over how many months this crop could be satisfactorily produced. Mr. Brown agreed in this view and decided to sow plots of sugar-beet at intervals over several months.

A consequence of this decision was that arrangements had to be made for the testing of the crops over a considerable period, and it was therefore decided to take this opportunity of also testing the local sugarcane as also other varieties of cane at the Tarnab Farm in as thorough a manner as possible.

A third investigation now presented itself. It is customary in that locality to bury sugarcane in December in order to preserve it for planting out in the following April. The crop is all harvested in December and January, and cane could not be suitably left standing in the field until the succeeding time of planting. The method of preserving the cane in "clamps" is therefore adopted, and for the end in view the method is very perfect. The question then occurred, does cane, which is preserved in this manner, deteriorate from the manufacturer's standpoint? We decided therefore to include some tests on this question The investigations had thus to do both with cane and beet.

Sugarcane.—There is a considerable area of sugarcane in the Peshawar Valley, which consists principally of a "thick" variety, yielding heavy crops. A number of samples, each consisting of about 200 canes, were tested in December and January and the following examples illustrate the general quality :—

Date.	Village.	Juice per cent.	In Juice.			
			Brix.	Sucrose per cent.	Glucose per cent.	Coefficient of purity.
28-11-13 .	Tarnab .	76·71	14·87	12·03	1·92	80·9
2-12-13 .	Zakki .	74·72	15·40	12·24	2·27	79·5
15-1-14 .	Tarnab .	76·92	15·60	13·10	1·67	84·0
19-1-14 .	Tarnab .	77·65	15·90	13·65	1·49	86·1
3-2-14 .	Tarnab .	...	16·10	13·89	1·39	86·0

The proportion of juice was obtained by crushing the cane in a Nahan bullock power mill. It will be seen from the above examples that it is a cane containing a high proportion of juice. United Provinces canes for example yield only some 60—65 per cent. juice to such a mill. The percentage of sugar in the juice is rather low. As the season advances the quality improves. From the manufacturing standpoint the comparatively low percentage of sucrose is made up for in a great measure by the high proportion of juice and low fibre content which reduces the necessary maceration. The crushing season is limited to the months December and January.

Other canes tested were imported varieties grown at the Tarnab or Haripur Farms, *e.g.*, Striped Mauritius, Purple Mauritius, Saharanpuri, Partabgarhi, etc., most of which proved to be similar in quality to the local *pounda*.

"*Clamped*" *cane.*—The method of "clamping" sugarcane in the Peshawar Valley is similar to that employed in Europe for preserving roots or potatoes. It may be

briefly described. The cane is taken up with the surface roots, leaves and tops intact. The canes are placed on the ground in a neat flat heap, canes lying parallel to one another, and covered with about 6″ of earth; they then remain undisturbed until the planting season in April. Two experiments were made in order to ascertain whether the cane depreciates when kept in "clamps"—the one was made early in December when four lots of cane, each of about 4·5 maunds, were put in "clamps," the cane being very carefully sampled* and tested at the time; the other was made on January 15th, when two lots of about 9 maunds each were clamped. The cane which was "clamped" in December remained for 21 days in the "clamp;" that of January was left until May and was tested at intervals of about one month. The data obtained are collected in the following statement :—

Composition of sugarcane before and after clamping.

Variety.	Date of putting in clamp.	Date when tested.	Juice per cent.	Juice. Brix.	Sucrose per cent.	Glucose per cent.	Coefficient of purity.
Striped Mauritius.	24-11-13	...	65·78	14·27	10·86	2·22	76·12
		15-12-13	67·27	14·10	10·60	1·92	75·19
Striped Mauritius.	26-11-13	...	71·96	15·09	12·11	1·61	80·27
		17-12-13	69·14	14·66	11·33	1·82	77·29
Local pounda .	28-11-13	...	76·71	14·87	12·03	1·92	80·93
		19-12-13	71·73	15·09	12·09	1·92	80·10
Local pounda .	2-12-13	...	74·72	15·40	12·24	2·27	79·50
		21-12-13	67·78	15·13	12·11	2·08	80·05

* For a discussion of errors in sampling sugarcane see *Mem., Dept. Agri., India, Chemical Series*, Vol. III, No. 4.

Composition of sugarcane before and after clamping—contd.

Variety.	Date of putting in clamp.	Date when tested.	Juice per cent.	Juice.			
				Brix.	Sucrose per cent.	Glucose per cent.	Coefficient of purity.
Local pounda .	15-1-14	...	76·92	15·60	13·10	1·67	83·99
A		16-2-14	76·31	15·20	12·22	1·85	80·37
		24-3-14	72·50	15·40	12·82	2·04	83·22
		24-4-14	70·73	14·90	12·66	1·52	84·91
Local pounda .	15-1-14	...	76·72	15·90	13·65	1·54	85·84
B		16-2-14	73·25	16·00	12·97	1·75	81·08
		24-3-14	72·40	15·10	12·11	2·00	80·21
		24-4-14	71·59	14·85	12·19	1·67	82·09

An examination of these figures shows that the following deductions may be drawn:—(*i*) There was probably some reduction in the proportion of juice in the cane, due to loss of moisture during the period it was in clamp. Whether this was so during December is doubtful, but it certainly occurred during the three months from January to April. This is almost to be expected owing to a certain amount of drying; at the same time it is to be remembered that there is the error due to sampling, especially when, as in February, March and April, canes had to be drawn out of the heaps. Another error rests with the mill, which cannot be always tightened up equally at different times. Regarding the sucrose, glucose and purity, these did not change during December, the small variations which were found by analysis must be attributed to experimental error chiefly in sampling. The results of the December experiments are indeed remarkably satisfactory. During the much longer period January to April, the individual tests of the experiment marked " A " exhibit some variations no doubt due chiefly to sampling, but it is evident that except that the cane dried somewhat, this lot of cane suffered no

appreciable change. The lot of cane marked " B " probably suffered some small depreciation, but it was subject to slightly different circumstances. It has been mentioned that the local practice is to take up the cane with its surface roots intact. If, however, this mode of preserving cane for a factory were adopted, it was thought that this factor would add somewhat to the cost, costing rather more to lift from the ground and rather more to carry. Hence the lot of cane marked " B " was clamped without roots, but with leaves intact. This cane, as also all the other, remained practically perfectly sound, only the cut ends of the cane showing signs of rotting. This factor probably accounts for the somewhat greater depreciation of the juice, though it may be also partly due to error of sampling.

In any case these experiments show that sugarcane may be preserved in clamps over considerable periods practically intact.

Gur.—A number of samples of the locally made *gur* were analysed. These varied (with one exception) from 70—74 per cent. sucrose, and from 12—15 per cent. glucose.

Sugar-beet.—Two varieties of sugar-beet were sown, namely, Vilmorin and Klein Wanzleben. One plot of the latter was sown on September 20th, and plots of the former were sown on October 10th and 20th, November 10th and 20th and February 20th. Germination and subsequent growth were very good and uniform. Tests of these plots were made frequently, commencing naturally with the earliest sown. The samples consisted at first, in each case, of about 20 roots taken from uniformly distributed points over the plot, which enabled one to form an opinion on the progress of sugar formation, and so soon as the roots appeared to be well grown, the number of the roots was increased to about 100 per sample, taken similarly from uniformly distributed points. Not only do such samples yield accurate information as to the quality of the crop, but, together with a knowledge of the number of roots per plot, indirectly of its weight.

For example the following instances may be quoted to show how well duplicate samples agree :—

Year.	Number of roots.	Average weight per root, grms.	Estimated weight per acre, tons.	Sucrose in root per cent.
1913	100	756	......	14·68
	100	711	......	14·73
1914	97	612	14·9	11·9
	96	647	15·8	12·3

The following conclusions were drawn regarding the beet root crop :—

(*i*) The average weight per root reached approximately 1 lb. at the end of six months from date of sowing if sown between September 20th and November 20th. Those sown on February 20th grew faster, and were fit to crush in June.

(*ii*) The percentage of sugar was found to be between 12 and 13 in Klein Wanzleben and between 10 and 11 in the Vilmorin when the roots were still quite small.

(*iii*) While the cold weather lasted the sucrose percentage remained rather low, but so soon as the hotter weather set in at the end of April there was a marked increase at least in all those sown on or before November 10th; thus we have :—

Sown.	Date of sample.	Sucrose per cent.
September 20th	April 21st	13·1
	May 7th	15·6
October 10th	April 22nd	11·2
	May 14th	15·3
October 20th	April 23rd	10·5
	May 15th	14·7

(*iv*) The percentage of glucose was about ·1 per cent. in each case.

(*v*) The coefficient of purity was found throughout to vary from 80—90.

(*vi*) The weight of roots was estimated to be about 20 tons per acre at the time of optimum quality.

(*vii*) The roots sown February 20th were not tested later than May 31st when the sucrose had risen to 12·2 per cent., but they were perfectly sound and growing well at the end of June.

It is thus fairly evident that sugar-beets of good manufacturing quality can be grown so as to be ready by the middle of March, and by sowing on successive dates, the supply could be maintained until the end of June.

This investigation of the sugar capabilities of the Peshawar Valley has thus shown that—

(*i*) sugarcane can be had in the field during December and January,

(*ii*) that sugarcane may be preserved in a sound condition in clamps over the months February and March, and

(*iii*) that a sugar-beet crop could be grown so as to supply a factory from the middle of March until the end of June. The factory would naturally have to be fitted to deal with both crops, but there should be no difficulty in arranging for this and the potential length of campaign, six or seven months, is unusually long.

Production of sugar-beet seeds.—A number of roots were transplanted for seed this year and some of these were tested at the time of transplanting, so that if seed is obtained, their progeny can be again tested and the process of selection of acclimatised plants commenced.

VII.—Milk.

Milk of Montgomery cattle.—Between December 1911 and June 1912 a series of tests of the quantity and quality of the milk of selected cows of the Montgomery herd at

Pusa was made in collaboration with my colleague Mr. A. C. Dobbs, then Imperial Agriculturist. The precautions which we employed in order to avoid experimental error as far as possible are dealt with in a succeeding paragraph.

Although the analytical part of the work was naturally completed day by day at the time, it was necessary, in order that the data obtained might have their full value, to examine them carefully and ascertain the probable errors mathematically. This portion of the work was done during the hill recess 1913, and explains why the subject was only briefly referred to in my last Annual Report.

Altogether three series of tests were made; with three cows in December and January; with twelve cows in April and May; and with ten cows in September to November. Most of these cows had calved recently and were in " full milk " or " fairly full milk."

Regarding the *yield* of milk, one half was obtained by hand milking (see succeeding paragraph) and from these data the total *production* of each cow was ascertained. This varied considerably, being as small as 8 lbs. in one case and as high as 18 lbs. and 21 lbs. respectively in two others. The majority produced from 10 to 14 lbs. per 24 hours. The *morning* and *evening* yields were found to be approximately equal in all cases; the periods between milking were 12 hours each. In respect of *fat* the percentage varied generally from 4 to 6, but was as low as 3·5 in one or two instances. The percentage of *solids-not-fat* varied from 8·2 to 9·0.

The *morning* and *evening* milk was not equally rich, the morning milk being systematically richer by about 1·0 per cent.; in some cases the difference was as small as ·3 per cent., in others as high as 1·5 per cent.; the mean difference for the 25 cows was ·91 per cent.

Tests of the yield and composition from *different parts of the udder* showed that :—

(*i*) Usually the *yield* is approximately equal from the right and left side respectively, though there

were five cows which produced more milk from the one than from the other half udder.

(*ii*) In respect of *fat percentage*, with one exception, the milk was of equal richness from either half udder. The *quality* of the milk from the several *quarters* of the udder was tested in December and January for three cows, and here characteristic differences were met with, for in one case the milk was systematically richer from the fore, than from the hind-quarter, in another case it was systematically richer from the hind, than from the fore-quarter, whilst the third cow showed no such characteristic differences. Whilst the number of instances is so small that one cannot say that such instances are not exceptional, the tests were conducted over so long a period, upwards of two months, that the data are not to be ascribed to accidental error; they are real differences for the two cows, however exceptional such cows may be.

Errors involved in making milk tests.—When we decided to make a series of milk tests of the Montgomery cattle, it was apparent that an attempt should be made either to avoid several errors which are liable to occur and which very frequently minimise the value of such tests, or to estimate their magnitude. These may be briefly summarised.

(*i*) The number of cows should not be very small. Only three were included in the first period, but twelve and ten cows respectively were employed in two subsequent periods.

(*ii*) If the periods elapsing between milkings are unequal, it is known that this alone affects both the quantity and quality of the milk. As there was no difficulty at Pusa in making these periods equal, all the cows were milked at 12 hours' intervals, the variation in length of this period being not more than 5 minutes, which is a negligible quantity.

(*iii*) In India it is usually difficult to persuade a cow to yield milk to the hand without the calf sucking at the same time. At Pusa this was found to be regularly so. But obviously if the calf takes an unknown quantity of the milk, the total yield cannot be correctly ascertained; and without the adoption of special precautions this factor affects the percentage of fat also. The practice at Pusa with this herd is to allow the calf to take all the milk of one side of the udder whilst the other half is hand drawn, the idea being to ensure that the calves have a liberal allowance. It remained therefore to ascertain whether this practice is accompanied by any systematic errors, *e.g.*, is the one half udder as thoroughly stripped by hand as the other half is by the calf? The system which we adopted for these tests was to allow the calf to take the milk from one half udder, say the right, whilst the left half was hand milked, for two milkings; then for the following two milkings the calf was given the left half, whilst the right half udder was hand milked; and this sequence was followed day by day. During the first half of the period, *i.e.*, approximately for one month, the change from right to left side was made at the morning milking, whilst during the second half period, it was made at the evening milking. By the adoption of this system of milking it was evident that if the calf obtained more milk than the man (*i.e.*, if the hand milking were the less perfect) or if more milk were secreted during the night or day time, *systematic* differences of yield would be perceptible in the records which could be traced to one of these two causes. The data showed no such systematic differences and it became evident that the calf and man were equally efficient in stripping the udder. The source of error due to not being able to milk these cows entirely by hand, was thus avoided.

An examination of the data, both of yield and of percentage of fat, showed that the probable error of *individual* tests was unusually small. The probable error of yield for individual milkings was only $\pm \cdot 27$, and for percentage of fat it was only $\pm \cdot 29$, which are small when compared with

similar records which have been obtained elsewhere. The principal deductions depended on the arithmetical means of all the tests of any one period, and the probable error then fell to rather less than $\pm \cdot 1$ both in the case of yield and percentage of fat. We were thus enabled to decide with great accuracy what differences were due to error of experiment and what were real differences in yield or quality.

Error due to milking in the ordinary way.—During a part (28 days) of the third period, September to November, the ten cows were hand milked as for profit, that is, the calf was allowed as little as possible, the object being to ascertain the magnitude of the errors which such a method would incur. The yields by hand were about 50 per cent. greater during this time, which was to be expected. It is also obvious that under such conditions the real quantity of milk secreted could not be ascertained. But in addition to this, the probable error of an individual milking rose from $\pm \cdot 26$ to $\pm \cdot 74$, that is, it became three times as great.

Detection of added water in milk.—During recent years the reliability of the freezing point of milk as a criterion of its freedom from added water has been recommended, chiefly by Brownlie Henderson in Queensland. It has been found by him and others that the freezing point of pure milk is so constant that a comparatively small addition of water, *e.g.*, 2 per cent., can be detected. At present the method is purely empirical and would only become dependable if a large number of tests showed what the variation of freezing point of pure milk is. To this end the freezing point of the milk of a number of individual cows and buffaloes at Pusa, at the Lyallpur Agricultural College and at the Military Dairy Farm, Peshawar, was determined, and it seems certain that even among individuals the variation in freezing point is only small. At Pusa it varied from $-\cdot 543°$ to $-\cdot 577°$C., at Lyallpur from $-\cdot 527°$ to $-\cdot 562°$C., and at Peshawar from $-\cdot 529°$ to $-\cdot 564°$C. The variations between individuals are naturally greater than between samples of the mixed milks of a herd; thus

the freezing point of cow's milk at Pusa was −·555°C., at Lyallpur −·547°, at Peshawar −·537°, and buffalo's milk at Peshawar −·552°. The standard freezing point assumed by Winter is −·550°C., and a freezing point −·537°C. is equivalent to 2·36 per cent. of added water. Thus for mixed milks 5 per cent. of added water could be detected with certainty, whereas if dependence is placed on the percentage of solids-not-fat, there are cases where 10 per cent. could not be sworn to. Using Pusa cow's milk, to which known amounts of water were added, the freezing point indicated the following percentages of water :—

Indicated.	Actual.
5·6	5·0
10·9	10·0
19·0	20·0
21·3	25·0

VIII.—Programme of work for 1914-15.

Major subjects :—

1. Examination of the sugarcane and sugar-beet crops at Peshawar and the storage of these crops in "clamps."

2. Experiments on possible improvements in the refining of saltpetre will be continued.

3. Records of the amount and nature of drainage water from fallow land and from land bearing crops are maintained.

4. An investigation of certain of the constituents of *Lathyrus sat.* is being conducted by the Supernumerary Agricultural Chemist.

5. The ratio of Argon to Oxygen and Argon to Nitrogen in soil gases under certain specified agricultural conditions is being determined.

Minor subjects :—

6. An attempt is being made to ascertain the nature of the hydration of clay in soils.

IX.—PUBLICATIONS.

The following have been issued :—

1. The Yield and Composition of the Milk of the Montgomery herd at Pusa and Errors in Milk Tests. J. W. Leather and A. C. Dobbs. *Mem. Dept. of Agri. in India,* Chem. Ser., Vol. III, No. 6.
2. The System Potassium Nitrate, Sodium Chloride, Water. J. W. Leather and Jatindra Nath Mukerjee. *Mem. Dept. of Agri. in India,* Chem. Ser., Vol. III, No. 7.
3. The systems (A) Water, Magnesium Carbonate and Carbonic Acid, (B) Water, Calcium Carbonate, Magnesium Carbonate and Carbonic Acid. J. W. Leather and Jatindra Nath Sen. *Mem. Dept. of Agri. in India,* Chem. Ser., Vol. III, No. 8.

REPORT OF THE IMPERIAL ECONOMIC BOTANIST.

(A. Howard, C.I.E., M.A., A.R.C.S., F.L.S.)

I.—Staff.

Charge.—I held charge of the section at Pusa during the year under review from October 18th, 1913, till June 30th, 1914. During the remainder of the period, I was on combined leave when the Second Assistant, Maulvi Abdur Rahman Khan, was in charge of current duties at Pusa. This assistant did good work during my absence and was rewarded by the grant of a charge allowance.

Staff.—The work of the staff continues to be satisfactory. In addition to the assistant mentioned above, the only case for individual mention is that of Lal Singh, who has been promoted to the post of Second Fieldman at Pusa. Fieldman Ram Prasad died during the year when the section lost the services of a loyal and hard-working man.

II.—Wheat Investigations.

Distribution of Pusa Wheats in India.

In previous annual reports, a full account has been given of the preliminary work connected with the production and also with the trial of Pusa wheats in the various wheat-growing tracts of India. At the same time, reference has been made to the investigations on the influence of the environment on the milling and baking qualities of these wheats, which have been carried out in collaboration with Mr. Leake and with the invaluable help of Mr. A. E. Humphries. It is not proposed to refer now in detail to these preliminary matters which were fully described in the annual reports for 1911-12 and 1912-13.

The outstanding feature of the work of the last year has been the demonstration of the fact that one of the new wheats, No. 12, is the best for general cultivation both in the Gangetic plain and also on the black soils of Peninsular India. This wheat has also given satisfactory returns, both as regards yield and quality, in the *barani* tracts of the Punjab where it is now being grown by the cultivators. The behaviour of this variety is of the greatest importance in the work of improving the wheats of India. Judged by the returns obtained by the people themselves, not only in almost every District from Gurdaspur in the Punjab through the United Provinces to Bhagalpur in Bihar, but also on the black soils in Bundelkhand and in the Central Provinces, this wheat has invariably given the highest yield. At the same time, it has been demonstrated that its milling and baking qualities have been maintained unimpaired, both under *barani* conditions and also under canal and well irrigation. In addition to the satisfactory yield, the numerous trials of Pusa 12 by the cultivators in the United Provinces, during the last wheat season, have brought out the fact that it is able to maintain itself with far less water than late sorts like Muzaffarnagar, which need at least one more watering. Pusa 12 is a red chaffed wheat with good straw and its characteristic appearance in the field is of considerable advantage in the work of replacing the country wheats, which for the most part are shorter in the straw and have white chaff. The grain is white in colour and larger and more attractive than Muzaffarnagar. A single improved grade of white wheat can now be grown over a very large portion of the wheat-growing area of India. This will be an enormous advantage to the export trade and at the same time will be of great use from the point of view of the food of the people. For local consumption, Pusa 12 is worth at least two annas a maund more than ordinary Indian wheat.

Pusa 12, when placed on the Calcutta market for the first time this year, found a ready market at the mills and fetched four annas a maund above Bihar wheats on its

appearance alone. This fact is promising from the point of view of the first shipment of this wheat to Great Britain.

The distribution of Pusa 12 to cultivators is now being actively taken up by the Agricultural Departments of the United Provinces, the Punjab, Bihar and Central Provinces and all the available seed has been distributed. The supply, however, was far below the demand and, in particular, the indents from the United Provinces could only in part be met. Steps have been taken to remedy this and it is expected that the seed farms in Bihar and some of the indigo estates will be able to provide about 10,000 maunds of Pusa 12 in April 1915 to supplement the general seed supply of the Agricultural Department. On the indigo estates in Bihar, Pusa wheats are now almost exclusively grown and wheats like Muzaffarnagar have been given up.

A beginning has been made during the present year in the work of growing sufficient Pusa 12 at a few centres in the Central Circle of the United Provinces so that the surplus can be sent as a special shipment to England for the purpose of introducing this wheat on the Home markets. The co-operation of Mr. B. C. Burt, the Deputy Director of Agriculture, has been secured in this matter and the necessary financial assistance has been given by His Honour the Lieutenant-Governor of the United Provinces and by the Agricultural Adviser to the Government of India. By taking advantage of the development of the Co-operative movement in this Circle, it is hoped to replace systematically, from certain centres, the country wheats by Pusa 12 over large areas. The experiment is an interesting one, not only from the point of view of the trade in an improved product, but also as a means of discovering how far the Co-operative movement can be used in the distribution of an improved variety in a systematic way.

Another aspect of the success of Pusa 12 over so large a portion of the wheat-growing area of India remains to be considered. It is sometimes stated that the agricultural conditions vary so much in India from province to province and also in different parts of the same province, that

the work of improving any widely cultivated crop can only be done locally and at a number of stations. In reality this idea is not supported by the facts. It is true of course that the conditions under which wheat is grown in India vary widely, and that a knowledge of these conditions is essential in the work of improving the crop. It is also true that a single area of fifty acres in the Gangetic alluvium, if skilfully selected, exhibits an exceedingly wide range of soil conditions, which, from the point of view of the requirements of the wheat crop, vary almost as much as any two of the wheat-growing provinces of India. By taking advantage of this circumstance, it is possible to make a single wheat-breeding station serve for almost the whole of India.

Wheat Breeding.

The fourth generation of the crosses between Indian and English wheats, referred to in the previous report, have been worked through during the year. A large range of individuals has been selected for further growth, all of which are characterised by strong straw, rust resistance and attractive looking grain. The range in time of ripening of these plants is very great. Some are earlier than Pusa 4 while among those with enormous tillering power are numerous individuals which will probably ripen too late for any of the wheat tracts of India except possibly the Quetta valley. This group of wheats is by far the most promising material obtained at Pusa. Some types will probably be fixed in 1915, after which they will be tried in the various wheat-growing tracts.

III.—Other Investigations.

Tobacco.—Progress continues to be made in the tobacco investigations at Pusa.

Further results have been obtained with the cigarette tobacco known as Type 28. A good many of the indigo estates in Bihar are now growing this tobacco for the Indian Leaf Tobacco Development Company at Dalsing Serai and.

in April last, an increased quantity of self-fertilized seed was distributed. The yield of this tobacco under estate conditions is very satisfactory and it is also being taken up by the cultivators for the local trade. On a few estates, Type 28 is being cured on racks, the price obtained for the first quality leaf being Rs. 25 per maund. Arrangements have been made to grow at Pusa the seed of this tobacco required by the planters and others so that this variety can be maintained true to type and natural crossing prevented.

The importance of improved methods of growing the seedlings of this crop was referred to in the last report. By partially sterilizing the seed beds, the seedlings grow faster and stronger and are ready for transplanting about a week or so earlier than when grown in the ordinary way. It is a great advantage in Bihar to be able to rely on an abundant supply of strong seedlings at the proper time so that even fields can be established on the *hathia* rains. Work is in progress at Pusa with the object of devising the most economic method of adapting the results obtained to estate conditions.

Interesting results were obtained during the year on green manuring for tobacco with *sanai* (*Crotalaria juncea*, L.). These results supplement those already published in the *Agricultural Journal of India* (Vol. VII, 1912). It was found then that if the interval of time between ploughing in the green crop and transplanting the tobacco exceeded two months, the effect of the green crop diminished and finally disappeared altogether. During the past year, the effect of diminishing the time between ploughing in the *sanai* and planting the tobacco was tried. It was found that any period less than two months was too short for the decay of the green manure and when the period was less than one month the crop obtained was very poor. Across the plots in which the *sanai* had less than two months to decay, a broad strip was subsoiled some time after the green crop was put under. The result was a great improvement in the vigour of the tobacco crop and the subsoiled strip stood out markedly from the rest. It is prob-

able that these latter results can be explained by the work of Kidd (*Proc. Roy. Soc.*, B, Vol. 87, 1914) who has shown that the decay of green manure produces so much carbon dioxide in the soil as to inhibit the germination of seeds. Until a certain stage is reached in the decay of a crop like *sanai*, it is quite possible that want of oxygen and excess of carbon dioxide would be limiting factors to a rapidly growing crop like tobacco. That a poor germination is obtained if seeds are sown soon after a green crop of *sanai* is ploughed in, was observed twice during the past year at Pusa, once in the case of Java indigo and once in the case of tobacco sown in a nursery which had been recently green manured with *sanai*. The absence of any marked crop increase on the heavy lands in Bihar, following a dressing of *seeth*, and also the poor crops obtained on such lands after *sanai* ploughed in (especially in wet years or when the soil is waterlogged by flooding) are probably also connected with oxygen supply. Kidd's researches are likely to prove of considerable interest to India.

A paper is in preparation, by the Personal Assistant, on the inheritance of characters in *Nicotiana rustica*. L., the observations on which were brought to a conclusion during the year.

Gram.—The selection work on this crop was continued and three of the most promising types, including the high yielding white gram which was valued so highly at Bombay in 1912, have been distributed for trial on estates in Bihar and also in other tracts of India. A certain amount of natural crossing takes place in this crop, the extent of which under Bihar conditions is now being investigated.

Fibres.—The work on the inheritance of characters in *Hibiscus Sabdariffa* was continued, but it was not found possible to complete this investigation during the year. The work is being continued.

The behaviour of some of the cultures of *sanai* (*Crotalaria juncea*) at Pusa indicated that extensive natural crossing takes place in this crop when two or more varieties are grown next to next. The pollination mechanism in the

flower has been worked out and the functions of the long and short stamens elucidated. Very little selfing under nets takes place in this crop, the flowers only setting seed normally after being visited by bees. These facts render variety trials in this crop exceedingly difficult.

Methods of pollination.—It is hoped during the next few months to bring out a second memoir dealing with natural cross fertilization and to include in it the observations of this subject made at Pusa since the first memoir was published in 1910.

Drainage.—The great importance of a system of surface drainage in Bihar, which allows each field to deal with its own rainfall only and also prevents the loss of fine soil by surface wash, has been observed for some years at Pusa. The subject has been brought to the notice of the planting community in Bihar in a paper read at the meeting of the Bihar Planters' Association in January last. The Pusa method has been taken up with success on several estates and a great deal of attention is now being devoted to the subject. On the Dholi Estate, the lands are being divided up into drained areas about five acres in extent so as to admit of the use of reapers and other labour saving devices in the cultivation of wheat for seed purposes. Mr. Danby, in a letter dated January 3rd, 1914, gives his opinion on this system of drainage as follows :—

" During the past year I have applied the system of surface drainage to some 40 bighas and I intend to extend it to the whole of my factory *zerats* here and at the outworks. The lands which I drained in this way this year were formerly, in a wet year, more or less waterlogged the whole of the rains owing to the water from the higher lands draining into them. This year I was able to cultivate and keep them clean all through the rains and even after the late rains which we had this year I was able to sow wheat in them before the end of October."

A note on the subject of drainage and soil denudation by rain wash was submitted to the Board of Agriculture at

Coimbatore. This has since been published in the *Quarterly Journal of the Indian Tea Association.*

Indigo.—The present position of the indigo investigations has been dealt with, in detail, in a report to the Bihar Planters' Association published in January last.

The area under Java indigo in Bihar has fallen since 1909-10 from 70,000 to about 15,000 bighas in 1913. During this period, the area under Sumatrana indigo has remained constant at about 45,000 bighas. The decline in the area under Java indigo has been a serious blow to the planting community in Bihar. As is well known, this species is much richer in indican than Sumatrana which latter was exclusively grown in Bihar till the introduction of Java indigo in 1898. The rapid increase in the area under the Java plant gave rise to the hope that the decline of the natural indigo industry would at least be arrested. Difficulties, however, arose after the cycle of dry seasons came to an end in 1908. The crop showed signs of falling off in vigour, the yield of leaf became less and difficulties in growing the crop for seed were of frequent occurrence. The poor seed sown gave rise to still more weakly crops with the result that the area declined eighty per cent. in four years. The cause of the trouble is regarded locally as a disease to which the name of 'wilt' has been given. The nature of the disease has been investigated both by the Sirsiah Experiment Station and also by the Mycological, Entomological and Bacteriological Sections of the Pusa Research Institute. In all cases the results obtained were negative. The matter was also referred to the Botanical Section at Pusa. It was found that the wilting of Java indigo, which takes place after the first cut in July, was due to the loss of the active root system of the plant, resulting from a long continued wet condition of the soil. Similar wilting is common in Bihar in crops like *patwa* (*Hibiscus cannabinus*) and *sanai* (*Crotalaria juncea*) when sown at the beginning of the monsoon for seed purposes. All these deep-rooted crops are sensitive to a constantly wet

soil and lose their active root system if this condition persists for too long a period.

In searching for some practical remedy for this trouble, two lines of attack suggested themselves. In the first place, improvements in surface drainage and aeration of the soil might be expected to prolong the life of the plant. Secondly, sowing the crop specially for seed towards the end of the monsoon, so that the developing root system would follow the fall of the subsoil water, was a second possibility in case improved drainage and cultivation failed to avert the trouble in the case of indigo grown in the ordinary way. Both these methods were tried simultaneously.

Among the various methods of surface drainage and interculture, tried during the monsoon on indigo cut for leaf in the ordinary way, no practicable remedy for the trouble was discovered. The waterlogging, which takes place in the fine Bihar alluvium and which leads to the destruction of the young roots of the indigo, cannot be entirely prevented by ordinary surface drainage and cultivation. The plants will not tolerate the constantly moist condition of the soil for the whole of the monsoon period.

In the case of August sown indigo, very different results were obtained. The plants grew rapidly, escaped wilt altogether and gave rise to a fine crop of healthy seed the following March. After reaping the seed, the plants were cut back and then gave a good crop of leaf in the ordinary way the following rains. Similar results were obtained on a large scale on the Dholi estate. The Pusa results showed that, for seed purposes, Java indigo should be sown thickly, in lines about two feet apart, early in August on high, well drained land in good condition. In this way the plants escape the disease. They grow to a large size by the end of October and so carry a heavy crop of seed the following cold weather. Thus one of the main obstacles to the cultivation of Java indigo in Bihar has been removed and the planting community are now in a position to grow their own seed without any great outlay. After gathering the

seed, the indigo can be cut back and good crops of leaf taken the following monsoon.

Attention has also been paid to the method of pollination in Java indigo, from the point of view both of seed growing and of improving the plant in indican production. Pollination by bees is the rule and very few seeds are produced by covered plants. As would be expected from the method of pollination, the progeny of single plants showed that natural crossing is common. These facts indicate that ordinary single plant selection methods in Java indigo are not likely to yield results at all commensurate with the work which this method would involve. Some system of mass selection, in which undesirable forms are eliminated prior to flowering, seems much more likely to lead to improvement. Advantage will have to be taken of those individuals in the mixed crop which grow rapidly and strongly and which by their habit of growth and amount of leaf surface are likely to give the highest yields of green leaf. These will have to be grown separately, away from other indigo, and a process of rogueing carried out before flowering time so that all undesirable types are weeded out and not allowed to cross with the rest. The fact that bees are necessary for the pollination of Java indigo indicates that for seed purposes the plants should be properly spaced and not grown too close together. Copious setting is obtained if the crop is grown in lines about two feet apart. Cultivated in this way, Java indigo branches freely from the ground and there is ample room for the bees.

During the progress of the indigo investigations it became evident that one important method of improvement had been, to a large extent, neglected. In the past, it has been tacitly assumed that the methods of cultivation in vogue in Bihar are more or less perfect and that any line of advance must necessarily begin in the laboratory. The results obtained at Pusa have shown that a considerable degree of improvement is easily possible in the actual grow-

ing of the crop. Further, these improvements are well within the means of an ordinary indigo estate.

After the removal of the cover crop, it is the usual practice in Bihar to weed the young indigo crop by hand. This process is tedious and expensive and the work is not always well done. By the use of lever harrows in the early stages, and by the use of spring tine cultivators later on, a great deal of hand weeding can be avoided and at the same time the young crop is greatly improved by the cultivation. These lever harrows have been tried extensively on the Dholi Estate for two seasons and Mr. Danby reports as follows on the trials (Letter, dated January 3rd, 1914) :—

" I meant to have written before about the lever harrows. I had six of these harrows in use last year and I have ordered six more from Messrs. Massey Harris.

" I harrowed practically the whole of my Java crop in February and March last after cutting the cover crop—wheat and *sursoo.* The crop was greatly improved by the harrowing, besides which the wheat stubble and weeds were to a large extent removed. I estimate that the amount saved in weeding alone in one year was more than the cost of the harrows."

Some consideration has been given at Pusa to the discovery of some practicable method of reducing the amount of wilt among Java indigo when grown for leaf. Very promising results were obtained during 1913. As is well known, the universal method of growing Java indigo in Bihar is to sow it either broadcast or by drills in lines close together. The result, in both cases, is a dense crop of unbranched plants among which leaf-fall rapidly takes place due to the crowding of the plants, thus leading to a great loss of indigo. Further, interculture to keep down weeds is impossible after the first cut. When the crop is reaped, the indigo is cut down completely and the plant has to produce new shoots during the monsoon at a time when its roots are in very moist soil. Few plants will survive uninjured such treatment during a heavy monsoon. When an indigo plant is suddenly cut down, the passage of

water and food materials from the roots goes on for a time and the stumps bleed. There are no leaves to carry on the transpiration current and the result is that the normal physiological processes in the plant are greatly upset. It is not surprising therefore that the new growth is formed so slowly and that it is often unhealthy. Many plants, such as peaches and flowering creepers like *Ipomœa*, usually die outright when cut down to the ground during the rains and hardly ever recover. It was decided in 1913 to try the effect of pruning the crop in July at the time of the first cut and to compare the behaviour of plants treated in this way with those cut down completely. The crop was grown in lines, two feet apart, to allow of branching. One half of the plot was cut down in the ordinary way, the rest pruned so that one branch was left at cutting time. The result was that the pruned plants began to shoot earlier than those which had been cut down and moreover escaped wilt to a much greater extent. The total yield from the pruned plot was about thirty per cent. greater than that of the area cut down completely. Work on this subject is being continued with the object of finding the most economic method of growing the crop so that it can be pruned at the first cut instead of being cut down completely.

IV.—The Development of the Fruit Industry of Baluchistan.

In the previous annual report, a complete account was given of the work at Quetta relating to the development of the fruit industry in Baluchistan. A brief reference to the progress made during the past year will suffice to bring this subject up to date.

Fruit and Agricultural Experiment Station.

Considerable progress has been made in the preliminary work relating to the laying out and equipment of the new Experiment Station at Quetta. The land has been laid out in large terraces with a suitable slope for irrigation in two directions. Water can now be brought on to about three-

quarters of the terraces by means of two bricked channels so that the loss of water during irrigation has been reduced to a minimum. The rest of the area is commanded by earth channels only. A pucca road now runs through the area, the farm buildings, which include quarters for the overseers and workmen, have been erected and the work connected with the artesian bores has been completed. One of these bores has been fitted with an oil engine and a centrifugal pump and has been very thoroughly tested by pumping on it for eight hours a day for a month. By this means the flow was increased from one to about three thousand gallons an hour without affecting the normal flow. A certain supply of irrigation water is now assured whatever may be the future of the large *Sirkhi karez* of which two *shabanas* of water belong to the Experiment Station.

The method of ring budding seedlings in May and June has proved a great success under Quetta conditions and during the past year about 2,000 budded trees have been distributed. All the young trees are pruned in the nursery during the first year's growth and properly trained before issue to the public. In order to check waste of stock, all the trees, except those for Government use, were sold at the rate of two to the rupee. At the end of the present year it is expected that from six to eight thousand trees will be ready for distribution.

Experience during the past year has confirmed the opinion given in the last report that by suitable methods of moisture conservation a great saving of irrigation water is possible in Baluchistan. Further saving of water is possible by a proper grading of the surface and by bricking the main distributaries. In the case of wheat, a yield of 18 maunds 30 seers per acre was obtained on an area of about three acres with one irrigation only. This was applied before sowing in October so as to ensure a good germination. Afterwards the soil moisture was conserved by means of a surface mulch produced by lever harrows. The ordinary yield of irrigated wheat near Quetta is not much over twenty maunds per acre and the usual number of waterings

is six to eight. The great saving of water possible by the use of a surface mulch in the case of a wheat crop is therefore obvious.

The growth of Persian clover (*shaftful*) as a green manure at Quetta continues to give excellent results. When sown in August, this crop gives three cuts of green fodder weighing about 60,000 lbs. per acre before the end of the following May. In addition, the last cut is either ploughed in as green manure or a crop of seed is raised. A marked improvement in the water holding capacity and tilth of the soil follows this treatment. A small amount of seed was distributed during the year and arrangements are being made to raise a large quantity this summer.

The investigations, referred to in the previous report, on the yellowing of peach trees have resulted in the discovery of the cause and of an easy method of prevention. In the vegetable gardens in the Civil Station of Quetta the peach trees have, as a rule, very yellow foliage, often accompanied by excessive gumming. Such trees die very quickly and do not bear a large crop once the unhealthy symptoms are well marked. The early symptoms appear to be identical with the disease in the Eastern United States known as " Peach yellows." The later symptoms of the disease, namely, premature reddening and ripening of the fruit, are however not developed. The yellow condition is not propagated by buds taken from affected trees and thus the disease is not the " Peach yellows " of the United States. Applications of soluble nitrogenous manures, such as nitrate of soda or sulphate of ammonia, gave negative results, so that want of available nitrogen is not connected with the trouble. It was found that if *shaftal* is grown round the affected trees the disease slowly disappears and the trees produce healthy growth. This result suggested that the yellowing of the foliage is due to want of air in the subsoil which follows the system of surface irrigation without any subsequent cultivation now in use at Quetta. During the present year this opinion has been confirmed. Some of the peach trees at the Fruit Experiment Station were over-irri-

gated by surface flooding during March and April last and by the beginning of May the new foliage showed the characteristic yellow tinge. Irrigation was stopped and the soil round the trees was well cultivated right down to the roots. In less than a fortnight the yellowness disappeared and the trees now show the characteristic shiny green foliage of vigorous growth. By growing the *shaftal* in beds between the lines of peach trees and by keeping the strip of soil, in which the trees occur, well cultivated the relations between air and moisture in the soil most suitable for the peach can be maintained. After the buds open in March the trees should only occasionally be watered directly as the roots get sufficient water when the beds of *shaftal* are irrigated.

The sale of improved fruit boxes to the public and the trade was continued during the year. These are now in general use at Quetta and during the present summer it is hoped to complete the experimental work on this subject and introduce several more improved packages.

During my absence on leave in 1913, Colonel Duke, I.M.S., Residency Surgeon and Chief Administrative Medical Officer in Baluchistan, kindly agreed to inspect the work from time to time and to give any necessary advice to the Assistant in Charge. This arrangement proved most useful.

V.—Programme and Publications.

Programme of work for 1914-15.

Plant breeding and plant improvement.—Work will be continued on the following crops on the lines indicated in the annual reports and in the publications of the section—wheat, tobacco, gram, fibre plants, indigo, oil seeds and fruit.

Publications.

Very little progress was made during the year in the publication of results. This part of the work is now in arrears, but a special effort is being made this summer to bring the publication of results up to date.

The following papers were published during the year :—

1. The Improvement of Indigo in Bihar (with G. L. C. Howard). Published by the Bihar Planters' Association.
2. Soil Denudation by Rainfall and Drainage. The Conservation of Soil Moisture. *Quarterly Journal, Indian Tea Association*, Part I, 1914.
3. The Seed Supply of the New Pusa Wheats (with G. L. C. Howard). Reprinted in the *Agricultural Journal of India*, Vol. IX, Part III, 1914.
4. Notes on Drainage and Green Manuring (with G. L. C. Howard). *Agricultural Journal of India*, Vol. IX, Part II, 1914.

REPORT OF THE IMPERIAL MYCOLOGIST.

(F. J. F. SHAW, B.Sc., A.R.C.S., F.L.S.)

I.—CHARGE AND ESTABLISHMENT.

Dr. Butler held charge of the section until 28th March 1914, when he proceeded on privilege leave and furlough; since this date I have been in charge of the section. I was absent on duty in Madras up to 31st October 1913, when Mr. McRae, Government Mycologist, Coimbatore, returned from leave.

S. Pasupati Iyer, second clerk, resigned to take up the Sericultural course on 22nd November 1913, and Nripendra Chandra Sen filled the vacancy thus caused until 26th March 1914, when Md. Taslim was appointed. All the staff have worked well.

II.—TRAINING.

Mr. A. C. Tunstall, Mycologist to the Indian Tea Association, worked in the laboratory as a visitor for about a week in September and Mr. G. H. Alington, I.F.S., Assistant to Forest Botanist, was deputed to study some tree diseases in January. Babu B. L. Gupta, B.Sc., Professor of Biology in the Reid Christian College, Lucknow, attended the laboratory during May and June and received a course of lectures and practical work on the morphology of the fungi.

III.—DISEASES OF PLANTS.

The investigation of the diseases of crops, the collection and identification of Indian fungi, and the giving of advice to cultivators and officers of the Department formed the principal work of the section.

(1) *Paddy Disease.*—The most serious disease of paddy is that which is known in Eastern Bengal as "ufra." An account of this trouble has been published in

Bulletin No. 34 of the Department while popular descriptions have appeared in the *Agricultural Journal of India* and in a Bengali leaflet. It has been established that the organism responsible for the damage is a form of eelworm (*T. angustus*) belonging to the genus *Tylenchus*, of which several species are known to cause serious diseases of cereals. Inoculations with material which, so far as could be determined, contained no other constant organism but the worm, have been successful in producing typical " ufra " in localities where the disease was quite unknown. The disease commences its ravages in July and culminates about September-October when large numbers of motile worms are present. After December they remain immotile and dormant in the dry grains and probably recommence activity only with the flooding of the fields after sowing; in this connection experiments have shown that *T. angustus* can withstand desiccation for even 15 months. It is a curious fact that transplanted paddy appears to be comparatively immune to natural attack. During the present year efforts have been made to map out the extent of the infected area and an experiment is in progress at Comilla to test remedial measures. It is probable that burning the stubble on the soil after winter harvest will be found to be the most efficient means of combating this disease. The infected area in Eastern Bengal appears to stretch from the Madhupur jungle north of Dacca to the river Mahari in Chittagong District. Westward the disease is bounded by the Padma but the eastern limit is uncertain, the infected area almost certainly reaches to the Meghna and further search is needed in the direction of Sylhet. In Tippera the northern limit of infection is near Akhaura on the Assam-Bengal Railway and the disease is particularly virulent in this district at Narjanpur, Comilla and Chandpur, at Begumganj and Chaumuhani in Noakhali District, and also at Fenni in Chittagong District. The most important fact in the distribution of this disease is that it has recently been identified with the " sanhra " condition of paddy in the Khunti Sub-Division near

Ranchi; further investigations will be carried out in this area.

The losses caused by "ufra" are very heavy. In Begumganj thana in 1910 the loss was estimated at 200,000 maunds of grain and in Chaumuhani in 1911 nearly half the winter crop was lost. The supreme importance of paddy as a food crop in Bengal and the virulence of this disease will make it the major work of this section for some time to come.

An account of *Sclerotium Oryzæ* Catt. was published as a memoir of the Department. This fungus has been found attacking rice in Burma, in Madras, and also in Bihar and Orissa, in which latter province it has been collected at Cuttack, at Pusa and near Ranchi. Paddy infected by this parasite usually shows excessive tillering and lightness in the grain, in fact there is frequently nothing within the glumes. In culture the morphology of the fungus proved more or less dependent upon the nature of the nutrient medium. The observations of Cattaneo, who regarded the sclerotia as spore containing organs, were not confirmed in the present memoir.

Brief accounts of Rice Bunt (*Tilletia horrida* Tak.) and False smut [*Ustilaginoidea virens* (Cke.) Tak.] were published in *Bulletin* No. 34. The former has been the cause of complaints from Germany, its spores having been found in rice imported from Burma and Siam. Effective remedies for this type of disease are known, should the trouble become severe.

(2) *Sugarcane disease.*—Complete accounts of the principal diseases of this crop were published during the year as memoirs of the Department.

"Red rot" has been the subject of previous publications of this section. In the most recent communication the authors have worked out the mode of air-borne infection in the field, a point which had long been obscure. It was found that infection took place chiefly at the adventitious root eyes, although penetration was also easy at the shoot

buds. The chief source of infection was the form of *Colletotrichum falcatum* which occurs on the mid ribs of leaves. The process of sett selection, described in previous publications, offers the best method of combating this disease. In districts where the local cane is badly diseased a fresh healthy type of cane should be imported and setts inspected carefully each year before planting. Fortunately in India we have a large range of these canes of hardy habit and great tillering power, which are relatively immune to red rot, and it has been found possible by hybridisation to combine the characters of such canes with those of the thicker, heavier yielding varieties of other countries. The introduction of new and immune varieties of cane has been very successful in Bombay Presidency. The Imperial Mycologist visited Surat in October last and concluded that while the present state of the cane was good an outbreak of disease must be expected unless there is a marked improvement in local cultivation. At present the canes are grown in low lands and are practically waterlogged. The adoption of the Godavari trench system or the nursery system of cultivation common in Ganjam is recommended.

The wilt disease of sugarcane was found to be due to the attack of *Cephalosporium Sacchari* Butl., a hitherto undescribed species. This disease strongly resembles "red rot," but in the case of infection by air-borne spores the plant was found to be far more susceptible to infection at stem wounds than in the previous case. The disease has been found at Surat, Poona, Samalkota and throughout North-eastern India. The control of the trouble should be on the same lines as in true red rot. As, however, wound infection is more common, the importance of removing diseased clumps before they have time to rot and set free spores is much greater. It is probable that this disease is incapable of doing permanent damage so long as the measures advocated against red rot, which are essential to the successful growing of thick cane in Northern India, are carried out.

"Collar rot" of sugarcane is due to the attack of *Hendersonina Sacchari* Butl., a hitherto undescribed genus. The outward symptoms are a withering of the top and a black rot of the roots; the lower nodes show a red discoloration in the pith. The roots and the base of the stem are full of the hyphæ of the fungus from which cultures are easily obtained. Both in cultures and on diseased canes a pycnidial stage was observed; the pycnidia are peculiar in containing two types of spores in the same loculus. Inoculations with pure cultures of the fungus were carried out at Samalkota and were successful in producing the disease. This disease occurs at Samalkota and at Jorhat; the extent of the damage caused by it is unknown.

Helminthosporiose of sugarcane is due to the well known genus *Helminthosporium*, of which *H. Sacchari* Butl. is a new species. This fungus is common on the leaves of sugarcane in Pusa where it produces small red discolorations. Inoculations with pure cultures were successful. The damage done by this disease is at present negligible.

Smut of sugarcane (*Ustilago Sacchari*) has been under observation in the Central Provinces and culture work with this fungus is now in progress at Pusa. "Sereh" of sugarcane was reported at Jorhat and Coimbatore during the year. The Imperial Mycologist visited Coimbatore in October last and satisfied himself that "sereh" disease was not present.

(3) *Palm diseases.*—During the year an outbreak of bud rot took place among the coconut palms of Malabar. The disease was investigated by the Supernumerary Mycologist, who was at that time officiating as Government Mycologist, Madras, and proved to be due to *Pythium palmivorum* Butl., the cause of the palmyra palm disease in the Godavari district. The fungus was studied in pure culture for the first time and inoculations were successfully carried out. It was found that the fungus was particularly active in producing rows of spots on the young leaves

of coconut palms. From such infections the fungus reaches the central bud by means of motile zoospores being washed down the leaves. Once the soft white leaf bases are reached a virulent rot takes place leading to the death of the tree. As the result of numerous observations on the discharge of zoospores it was concluded that the fungus probably belongs to the genus *Phytophthora* and not to *Pythium*.

Active measures, on the lines of those in operation in the Godavari, have been taken against the disease by the Government of Madras. A popular account of this trouble has been published in the *Agricultural Journal of India* and the more scientific results have appeared in the *Annales Mycologici*.

A "collar rot" of areca palms has been identified in Sylhet and Khulna and is probably due to *Fomes lucidus* (Leys) Fr. This fungus also occurs on *Guazoma* and pure cultures have been obtained from this source by Mr. Hafiz Khan. Inoculations have shown that the fungus is a true parasite on *Guazoma* and work is being continued on the areca palm.

(4) *Rhizoctonia.*—In January last there was a bad outbreak of disease on Pusa Farm due to this fungus. The crop affected was chiefly mustard, but the parasite was almost omnivorous. The fungus was *Rhizoctonia Napi* West—a species not previously observed in India. It is under observation in pure culture; it appears to be incapable of growth at the temperature of the hot weather and rains in Pusa.

A rot of stored potatoes at Sabour and Bankipore was also due to *Rhizoctonia*. The species *R. Solani* Kühn was common and in one case a very bad rot was identified as due to *R. destruens* Tass. The latter fungus was also a virulent parasite on *Delphinium* at the Alipore Horticultural Gardens, Calcutta; in fact it was its occurrence on this plant which enabled it to be identified on the potato.

At the beginning of the year numerous specimens of diseased poppy plants were received from the officials of the

Opium Department in the United Provinces. The specimens were infected sometimes by *Rhizoctonia* and more rarely by *Peronospora arborescens* (Berk.) de Bary. I visited Basti in March and concluded that the diseased condition of the poppy crop was due rather to the practice of keeping certain fields under poppy year after year than to any parasitic infection. The fungi found on the plants are a symptom rather than a cause of the condition of the crop. Investigation will be continued next season.

(5) *Cotton and Sesamum wilts.*—An attempt was made to define the southern limits of extension of cotton wilt, which the previous year had been traced from the Central Provinces to Belgaum. It was found to be present very sporadically in Bellary District, presumably as an extension from the Dharwar side, but a careful search at Guntakal in Anantapur District and Nandyal in Kurnool District failed to show any trace of the disease. As no reports of its occurrence elsewhere in Madras have been received, it may be assumed that only the extreme north-west of the Presidency has been reached. On the other side typical cases have been received from the Nadiad Farm near Ahmedabad though the disease appears to be little prevalent in Gujarat. Cotton wilt is, therefore, present in the western part of the Central Provinces, practically the whole of Bombay, exclusive of Sind, and the north-west corner of Madras. It is severe in parts of the Berars and threatening in parts of Khandesh, but elsewhere, at present, does little damage. The cause was definitely established during the year to be a species of *Fusarium*, successful inoculations with pure cultures of the fungus having been secured. Through the kindness of the United States Department of Agriculture an opportunity was obtained of comparing the Indian cotton wilt fungus with *Fusarium vasinfectum* Atk., the organism which is the cause of cotton wilt in America. There are considerable differences between the two parasites and it is probable that the Indian fungus is a distinct species. It is also probable, though accurate information on this point is

not yet available, that the Indian disease is decidedly less virulent than that in the United States. India is fortunate too in possessing a race of cotton, "buri," which is absolutely immune to the disease. Arrangements have been made, through Mr. Clouston, Deputy Director of Agriculture, Central Provinces (to whom the discovery of this property of "buri" cotton is due), to supply seed of this variety for trial in the United States in wilt infected tracts, and in return we are to receive American wilt-resisting varieties for trial in India. There is no other known method of fighting *Fusarium* wilts but by the growth of immune or resistant varieties.

Sesamum wilt has also been proved to be due to a *Fusarium*, and cross inoculations have confirmed what was already probable from morphological study, that the cotton and sesamum diseases are distinct and are due to different species of *Fusarium*. It is, in artificial inoculations, a much more virulent disease than the cotton wilt, proving fatal in every case tried—several hundreds. No resistant variety is known, but the cold weather (*rabi*) crop is less subject to the disease than the monsoon (*kharif*) varieties. Further work on these diseases will be resumed when opportunity arises.

(6) *Phytophthora investigations.*—The potato blight due to *Ph. infestans* (Mont.) de Bary, was investigated by Mr. J. F. Dastur, First Assistant. It was discovered that the fungus does not survive in the heat of the plains of India and is not therefore likely to become a serious pest, except possibly in the hills. A species of *Phytophothora* has also been discovered attacking *Vinca* and *Petunia;* it is a variety of the *Ph. parasitica* on castor which has been the subject of a recent memoir. The slight variation in measurements and a few differences in the inoculation experiments may be accounted for by the influence of the host plant.

(7) *Anthracnose.*—This disease has been investigated upon the betel vine, plantain, chilli and papaya. In the case of the betel vine the perfect stage of the species of *Colletotrichum* has been discovered to be an Ascomycetes

and the *Colletotrichum* and *Glœosporium* upon chilli have been proved to be one and the same fungus. The most important feature of the work on this crop is that the disease appears to be transmitted through the seeds. Various methods of seed treatment will be tried during the current year and experiments will also be conducted in the spraying of plantains against anthracnose.

(8) *Groundnut leaf disease.*—The relation between the incidence of the *tikka* disease of groundnut and the amount of cultivation and export of that crop was the subject of an inquiry during the year under review. Between 1894 and 1902 the export of groundnuts fell from 78,488 tons to 2,890 and the trade became practically extinct. The fall in the exports was due not to any deterioration in the quality of the produce, but to a marked decrease in the yield per acre, which appeared to be the result of a fungal disease, known locally as *tikka.* Treatment with fungicides had no effect in stopping the disease and, in 1902, the Bombay Department of Agriculture commenced the introduction of exotic varieties. These varieties were also attacked by *tikka,* but some, which ripened early, did not have their yield appreciably affected. Two varieties from Japan were especially useful in forming their nuts before the disease was sufficiently established on them to damage the produce. As a result of this, the exotic varieties, introduced by the Bombay Department of Agriculture, have now replaced the indigenous in all districts except the Poona district. Moreover by 1912 the *tikka* disease had decreased to such an extent that, in the whole Bombay Presidency, diseased specimens could only be obtained on the Manjri Farm. Coincident with the introduction of exotic varieties and the decrease in the amount of *tikka* disease the exports began to rise. In 1902 they were 2,890 tons, in 1906 they were 6,527 tons, in 1909, 23,934 tons, and in 1912, 48,801 tons. This is probably one of the most marked cases on record where a crop disease has been checked and a trade rejuvenated by the introduction and acclimatisation of new varieties.

(9) *Other plant diseases.*—A trial was made of the hot water treatment, which is so useful in the case of oat smut, against smut of bajra; the treatment proved useless. The treatment of oat smut by formaline steeping was successfully demonstrated on several estates in Bihar. Investigations into phanerogamic parasites and in particular the influence of chilli saltpetre on *tokra* of tobacco were resumed.

IV.—Systematic Work.

There were 505 additions to the herbarium during the year under review. Of these new additions we are indebted to the Bureau of Science, Manilla, and to mycologists in Berlin for 269 species. Named collections of Indian Fungi were sent in exchange. Collections of fungi for naming were received from, and duplicates were issued, if required, to the Mycological Officers of Provincial Departments of Agriculture and the Curator, Royal Botanic Gardens, Calcutta.

The systematic study of the large collections of *Deuteromycetes* (*fungi imperfecti*) in the Herbarium was taken up and material obtained for a fifth part of the *Fungi Indiæ Orientalis;* the series is being published in collaboration with H. & P. Sydow, Berlin.* At least one other part will be required to finish this large group.

A short paper was published describing the complete stages of the rusts of sugarcane, figs and *Oldenandia.*

V.—Miscellaneous.

The Imperial Mycologist attended the Board of Agriculture in December and the centenary celebrations of the Indian Museum in January. Assistance was given to the Imperial Bacteriologist in the identification of a fungus isolated from bursati tumours and in an inquiry into the relationship of fungi parasitic upon fodder to certain cattle diseases. In collaboration with the Imperial Agricultural Bacteriologist an examination was conducted

* This work will perforce stop during the war.—F. J. F. S.

on the fungi concerned in the fermentation of rice in the production of indigenous beer. The chief fungi present were *Mucor Prainii* Nech., *Mucor javanicus* Wehm., *Cladosporium Chodati* (Nech.) Sacc., *Rhizopous Cambodja* (Chrz.) Vuill.

VI.—Programme of work for 1914-15.

(1) *Research and experimental work.*—The investigation of some diseases of rice will be continued. The present stage of the investigations is given in *Pusa Bulletin* No. 34, 1913 " Diseases of Rice " and *Memoir, Botanical Series* VI, No. 2, 1913 " A sclerotial disease of Rice." The work will be continued particularly with a view to filling up gaps in our knowledge of the life-history of the organism which causes " ufra " disease, to the explanation of the apparent immunity of transplanted paddy to this disease, and to testing methods for its control. An obscure diseased condition of rice, known in parts of Bihar as " chatra," will be studied. Both these are major investigations. With regard to the other diseases of rice, none appear at present to be of great practical importance, and the investigations will be confined chiefly to the life history of the parasites concerned.

The investigation of the fungus diseases of sugarcane will be continued. Two *Memoirs* (*Botanical Series* VI, Nos. 5 and 6) containing the results of the work up to date, were published in 1913, and deal with the methods of infection and control in red rot of sugarcane, and with the symptoms and cause of three undescribed cane diseases, two of which have been sometimes confused with red rot. Future work will, for the present, be considered as of minor importance and will include a more detailed study of one of these diseases, " collar rot," and its connection, if any, with the sereh-like degeneration of cane known in several parts of India, and also the extent to which soil infection occurs in red rot.

The study of the wilt disease of cotton and sesamum will be continued on the lines described in *Memoir,*

Botanical Series II, No. 9 " Wilt disease of Pigeon pea." No results of sufficient interest to justify publication have yet been gained in connection with these diseases, which are of sufficient importance to be considered as amongst the major diseases of crops in India.

The work on potato blight recently commenced may also require to be treated as a major investigation if the disease recurs in the Gangetic Plain, where there was a severe outbreak last year. It is hoped to study the growth of the parasite in artificial culture and in particular to investigate its temperature relations as it is in this direction that its control appears to be most hopeful. As minor investigations the study of some allied parasites will be undertaken. Two of these have been studied in detail and the results published as *Memoirs, Botanical Series* V, Nos. 4 and 5, 1913, since the submission of the last programme to the Board.

The opium poppy blight has usually been believed to be caused by an allied fungus to the last mentioned group, but evidence was obtained last year, when the disease was severe, which suggests that this is not the case, but that the cause is a species of *Rhizoctonia*. The investigation of this disease will be directed to ascertain the true cause and to test methods of control. The study of other diseases caused by *Rhizoctonia* will be continued as occasion arises, and as sufficient material has been accumulated to undertake a more detailed study of this genus, it will be considered a major investigation.

The study of certain green parasites of crops will be continued. Little is known of these parasites in India and it is of importance to investigate their biology, particularly with reference to possibilities of checking the damage caused by them. The investigation has only recently been commenced and has not yet given any definite results.

Some preliminary work on soil fungi has been commenced and it is hoped to develop this as time permits, particularly with a view to elucidate the action of

fungi in assisting in the decomposition of organic matter. The subject may prove of interest in connection with green manuring, but it is not possible, as yet, to indicate on what lines it will develop.

A number of minor investigations of diseases of crops and fruit trees are in progress or projected. New work of this nature continually arises and it depends on the time available for their study and the relative importance of the disease as to whether they become major or minor items of the work of the section.

(2) *Training.*—This will be continued on the lines indicated in the Prospectus. Short courses will also be given if any students of the Institute wish to attend.

(3) The routine work of advising on plant diseases will be continued and assistance will be given as usual to Provincial Departments of Agriculture, the Forest Department, Planters' Associations and the general public.

(4) It is hoped to make further progress with the publication of descriptive lists of Indian fungi in the series "Fungi Indiæ Orientalis," of which four parts have already been published in collaboration with Messrs. H. & P. Sydow of Berlin, and a fifth is in preparation. The extension of this series to include the groups not yet dealt with is the most important part of the systematic work of the section and is very necessary. Minor papers on systematic mycology will also, probably, be published.

VII.—Publications.

Butler, E. J. . . . Ufra disease of Rice. *Agri. Journ., India,* VIII, July, 1913 (also Bengali translation).

Butler, E. J. . . . Diseases of Rice. *Bull. Agri., Res. Inst., Pusa,* No. 34, 1913.

Butler, E. J. . . . *Tikka* disease and the introduction of exotic groundnuts in Bombay Presidency. *Agri. Journ., India,* IX, January, 1914.

Butler, E. J. . . . Notes on some rusts in India. *Annales Mycologici,* XII, 1914.

Butler, E. J. . . . Report on Mycology for 1912-13 for Board of Scientific Advice.

Butler, E. J., & A. Hafiz Khan. Red Rot of Sugarcane. *Mem. Dept. of Agri., India*, Bot. Ser. VI, No. 5, October, 1913.

Butler, E. J., & A. Hafiz Khan. Some new Sugarcane diseases. *Mem. Dept. of Agri., India*, Bot. Ser. VI, No. 6, December, 1913.

Butler, E. J., & Saccardo, P. A. Fungi Indici. *Annales Mycologici*, XII, No. 3, 1914.

Shaw, F. J. F. . . Sclerotial disease of Rice. *Mem. Dept. of Agri., India*, Bot. Ser. VI, No. 2, July, 1913.

Shaw, F. J. F. . . The Mahali disease of Areca-nuts. *Leaflet No. 7 of 1913 of the Dept. of Agri., Madras.*

Shaw, F. J. F., & McRae, W. The Bud Rot of Coconuts in the Malabar District. *Leaflet No. 10 of 1914 of the Dept. of Agri., Madras.*

Shaw, F. J. F., & S. Sundararaman. Bud Rot of Coconuts in Malabar. *Agri. Journ., India*, April, 1914.

Shaw, F. J. F., & S. Sundararaman. Bud Rot of Coconuts in Malabar. *Annales Mycologici*, XII, No. 3, 1914.

REPORT OF THE IMPERIAL ENTOMOLOGIST.

(T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.)

I.—CHARGE AND ESTABLISHMENT.

Mr. H. Maxwell-Lefroy resigned his appointment as Imperial Entomologist from 1st December 1912 and I was nominated to succeed him and my services were transferred to the Government of India from that date but I was retained temporarily in Madras until relieved there, so that it was not until 1st December 1913 that I actually took over charge as Imperial Entomologist. Mr. A. J. Grove, Supernumerary Entomologist, who was in temporary charge of the section pending my return from Madras, was lent to the Punjab from 27th January 1914 to carry out work on grain pests and cotton bollworm, and remained in the Punjab until the close of the year under report. Mr. C. S. Misra, First Assistant, was on duty throughout the year and has carried out his work in a uniformly satisfactory manner; he has given his attention especially to the examination and record of the crop-pests of the cultivated areas of the Pusa Estate, to the collection of information regarding fruit-pests, and to the study of cotton bollworms and their parasites, of *Pyrilla* and of *Aleurodidæ*. Mr. C. C. Ghosh has been employed in the usual routine work of the rearing of insects in the Insectary. Mr. G. R. Dutt, as in previous years, has looked after the economic records and the *Hymenoptera* Collection. Mr. D. Nowroji has looked after the General Collection of Insects, especially the *Coleoptera*. The duties of these two assistants must naturally tend to increase considerably every year as the collections and records are augmented. Mr. M. N. De is borne especially for Sericultural duties and has been in charge of the silk work during the year and has carried out his duties with zeal and intelligence.

II.—Training.

Two students were under training in General Entomology during the year; one came from Travancore and completed his course on 30th September 1913, the other from Assam finished his training on 31st October 1913. No students are now under training; one man was to have been sent by the Punjab in June 1914, but it is understood that his course has now been postponed for a year. As all the provinces have now got a staff of trained assistants it is obvious that only occasional students are likely to be received at Pusa for training in Entomology, as there is no sign of any demand for a knowledge of this subject for its own sake and except as a means for Government employment. The lack of demand for training has, however, this advantage, that the Pusa staff is able to devote more time to research work.

III.—Tours.

I was away from headquarters in Madras from 1st December 1913 to 8th January 1914, attending the meeting of the Board of Agriculture and going over collections and records at Coimbatore. On 6th March I went to Nagpur to examine the Agricultural students in Entomology and returned on 15th March. On 22nd March I left Pusa again for Madras to examine the students there and to get in touch with the new Government Entomologist. I also visited Ceylon to see the local arrangements regarding plant imports and Coorg to see the extent of spread and control of the green scale on coffee, and returned through Bombay to see the entomological work there, arriving back at Pusa on 8th June. During this tour I also saw the Customs Officials at various ports which have been proposed as entry ports under the new Pest Act, and collected considerable information regarding plant imports into India. Mr. Grove toured in the Punjab from 8th August to 13th September, and visited Sabour in October and Siripur in November. Mr. Misra was sent on special duty to Karauli State from 2nd November to 6th December to establish the Lac Industry there; he also toured in Madras, Bombay and

the Central Provinces from 25th January to 12th March with the especial object of obtaining information on pests of fruit-trees. Mr. Ghosh visited Darjiling and Naini Tal in September to see the methods of bee-keeping practised there. Mr. De visited Assam in February to obtain information regarding Eri and Muga silkworms.

IV.—Provincial Work.

The entomological work of the Provincial Departments of Agriculture is to a large extent supplementary of and interdependent on that done at Pusa. Except in Madras, none of the Provincial Entomological Assistants are placed under the control of a qualified expert able to check their work locally and under such circumstances a Central Institute can fulfil a very useful function in checking and correlating their work besides acting as a centre for information regarding life-histories, records of occurrence and means of control of insect pests. Some provinces have taken full advantage of this fact in the past and have worked in close touch with Pusa; others have not done so hitherto, but it is hoped that, as a result of efforts now being made, they may do so in future.

In Madras the Deccan Grasshopper work was continued in the Bellary District but the failure of the rains at the commencement of the monsoon caused the destruction by drought of the early-sown crops in the area attacked so that the control-operations proved abortive on this account. The Entomological Laboratory fittings and the Insectary at Coimbatore were completed during the year and the collection rearranged in the new boxes. A large amount of information on insect pests was amassed and much of this was utilised for a book on South Indian insects which was written and completed by myself before leaving Madras. My successor, Mr. E. Ballard, who had been Government Entomologist in Nyasaland for the preceding two years, joined his new appointment at Coimbatore in January 1914 and has since been engaged in familiarizing himself with the insects of the Madras Presidency.

In Bombay there are now only two Entomological Assistants employed, one as Lecturer in the Agricultural College at Poona, the other in the Northern Division of the Presidency. The Third Assistant, who was stationed at Dharwar in the Southern Division, has been transferred to the Agricultural Section and his post has not been filled. Special attention has been paid to the occurrence and control of *Schœnobius bipunctifer*, which is a serious pest of rice.

In the Central Provinces two Entomological Assistants are employed, one for teaching at the Agricultural College at Nagpur, the other for fieldwork and demonstration. The latter made numerous notes on insect pests and exhibited show-cases and lectured and demonstrated control-methods at numerous Agricultural shows to audiences aggregating about nine thousand cultivators. Large numbers of *Canthecona furcellata*, a Pentatomid Bug predaceous on caterpillars, were bred and liberated in cotton and gram fields to check attacks on these crops by caterpillars.

In the United Provinces, demonstration was made in the Farrukhabad District of methods of storing seed potatoes to avoid attack of the Potato Moth (*Phthorimœa operculella*) which is now widely distributed in these provinces, though as yet it has apparently not reached the Hill Districts.

In the Punjab the work done has mainly been on pests of cotton and stored grain. Living specimens of *Rhogas*, a Braconid parasite of the cotton bollworm (*Earias*), have been supplied from time to time from Pusa.

In the North-West Frontier Province one Entomological Assistant works under the Agricultural Officer. The sugarcane crop is reported as badly infested with borers this year, over 50,000 egg-clusters having been picked from one experimental plot of six acres. *Gelechia gossypiella* is stated to have done considerable damage to last year's

cotton crop, but it is observable that late-ripening varieties were attacked most severely, local cotton (*Gossypium neglectum*), which ripens and is picked before the middle of October, practically escaping attack. Living specimens of *Rhogas* were supplied from Pusa and set free in the cotton-fields of the Agricultural Station at Tarnab, but it is doubtful whether they have established themselves. A Jassid bug, attacking grape-vines in the vineyards situated in the lower parts of the Peshawar Valley, has also been under investigation.

In Bihar the entomological work has always been done in close touch with Pusa and this has been the result of policy rather than of the contiguity of the two localities. An account of the more important pests was prepared some three years ago and was issued at the close of the year under review as a Crop-pest Handbook. The most important work undertaken has been the control of *Agrotis ypsilon* on the Mokameh Tal and the storage of potatoes. At Mokameh a regular campaign was undertaken and during the season 39,000 caterpillars were picked and destroyed on the high lands, whilst 34 traps destroyed 893,320 moths of which about 41 per cent. were females. On account of abnormal flood conditions and other factors, the attack was unusually serious, some 5,000 bighas of *rabi* pulse crops being destroyed. A similar campaign was undertaken against the same insect for the first time at Colgong and Ghogha, where 21 traps destroyed 43,874 moths whilst 337,600 caterpillars were handpicked from the high lands which were first attacked; the attack, which normally extends over an area of 8,000 bighas, was reduced to a nominal damage over about 20 bighas as a result of the above-mentioned efforts. The storage of seed potatoes has of late years presented great difficulties in Bihar, as in other provinces, as a result of the introduction into India of the Potato Moth (*Phthorimæa operculella*). Storage under dry sand has proved fairly effective in the districts South of the Ganges and Government godowns were started at Bihar, Bhagalpur, Colgong and Sabour in order to demonstrate the practicability and

advantages of this method. Storage was done satisfactorily in all these places and the method of storage is becoming popular amongst the cultivators and others interested. That this method is actually being adopted is shown by the fact that at Patna and Bihar in 1913 no less than 1,520 persons stored 122,285 maunds of potatoes under sand, as compared with 16,613 maunds stored by 399 persons in 1912, and 8,000 maunds by 200 men in 1911. Another pest of stored potatoes in Tirhut is a Tingidid bug (*Recaredus* sp.) and experiments are being made to find a successful method of control, as sand-storage is found to induce rotting of the potatoes in the damp climate of Tirhut.

In Bengal the Entomological staff only includes one Collector who is employed under the Government Botanist. He was chiefly occupied in dealing with pests of rice and also attended the Agricultural shows at Barasat, Khulna, Suri, Brahmanburia and Kamarchar where he explained insect pests and their life-histories and demonstrated the use of control methods.

The Entomological Assistant in Assam only went to his province in November 1913 after completion of his training at Pusa.

In Burma there is one Entomological Assistant, who was chiefly employed on the collection of information regarding insect pests of rice.

V.—Work at Pusa.

Investigation into the life-histories of injurious and other insects was continued, the following insects being those of which at least complete life-cycles were obtained :—

Pyrilla aberrans.
Aleurodes bergi and *A. citri.*
Atractomorpha crenulata.
Eublemma olivacea.
Odoiporus longicollis.
Virachola isocrates.

An unidentified Dermestid beetle on Stored Wheat.
Harpactor costalis.
Canthecona furcellata.
Syntomis cyssea.
Taragama siva.
Polyocha saccharella.
Dolycoris indicus.
A Psocid on *Loranthus.*

Figures of the various stages of most of these insects have been drawn and will be utilized for Memoirs on the insects concerned.

The subject of natural enemies (parasites and predators) of crop-pests is of great importance in India and a start is being made to collect information on the subject. Special attention has been paid to the parasites and hyperparasites of cotton bollworms (*Earias* spp.), of *Achæa melicerta* and of *Pieris brassicæ.* Parcels of *Earias* larvæ parasitized by *Rhogas lefroyi* were sent to the North-West Frontier Province and the Punjab to endeavour to assist control of this pest. There is no doubt that in the near future such control-methods will be found to be applicable in many cases, especially in the case of introduced pests, and we are already receiving numerous inquiries from abroad (notably America and Italy) regarding parasites of destructive crop-pests, and an attempt is being made to procure a parasitized colony of *Aleurodes citri* for export to Florida where this insect has done vast damage to the orange industry. In this connection it is of interest to note that an apparently identical parasite has also been reared from *Aleurodes ricini*, which occurs commonly on Castor in India, and specimens of the two parasites have been sent to Washington for exact determination, as their identity, if established, will be of practical importance.

Attempts have been made to trace *Agrotis ypsilon* through the hot weather and rains, as it is not known in what stage the insect passes this period on the Mokameh Tal, if it is actually present then at all. Incidentally, in

collecting the larvæ, it was found that they are preyed upon extensively by a Carabid beetle (*Broscus punctatus*).

The study of insects affecting stored grain was continued by the Supernumerary Entomologist, and the life-histories of *Æthriostoma undulata*, *Tribolium castaneum* (*ferrugineum*), and *Rhizopertha dominica* have also been worked out by Mr. Nowroji.

Special attention has also been paid to the insect pests of paddy and sugarcane, and large numbers of insects have been bred out and their study will be taken up when sufficiently long series are secured both from Pusa and the provinces. It may be noted here that paddy stubble, collected in the fields at Pusa in February, showed that about forty per cent. of the stalks contained borers.

Work on Termites has been continued and determinations of upwards of four hundred lots of these insects were received from Professor Nils Holmgren, of Stockholm; the identification of this material not only increases by some twenty species the list of known Indian forms, but will prove of great assistance in the discrimination of the various kinds found to do damage and in the writing up of a large accumulation of notes on their bionomies and occurrence. Wood treated by various processes was examined in February 1914 and some of the pieces of Powellized wood were found to be attacked by *Microtermes obesi* (*anandi*). This process is therefore not so infallible as has been claimed. Examination of some of the other series indicated that exemption from attack depends on the variety of the wood itself as well as on the method of treatment and in addition to the preferential tastes shown by the various species of termites locally prevalent; this point scarcely seems to have received proper consideration hitherto and it is proposed to initiate further series of experiments.

The green scale, *Coccus viridis* (*Lecanium viride*), which has proved such a serious pest of coffee in Ceylon and Southern India, first invaded Coorg in 1913 and bids fair

to become a serious pest there also. In May 1914 I visited Coorg, saw the affected areas and advised the planters on the subject. The scale was found to be parasitized to a very slight extent by a minute Chalcidid, apparently a species of *Coccophagus*, which has been sent to Washington for exact determination.

A consignment of *Microsporidium polyhedricum* in dead silkworms was received from the Government Entomologist, Egypt. This organism is said to be effective in the control of *Prodenia litura* in Egypt, but experiments at Pusa, conducted with the help of the Imperial Agricultural Bacteriologist, gave negative results with silkworms and larvæ of *Prodenia litura*.

An event of the year which deserves mention in this report is the passing of the Insect Pests Bill (Act II of 1914) for controlling the importation into British India of living plants which might otherwise bring in noxious insects in the future as they have done in the past. A Notification has been issued regarding certain specified crops, but this is aimed rather at the importation of fungal diseases, and a second Notification will doubtless be issued regarding all plants which are likely to bring in insect pests.

Under the Wild Birds and Animals' Protection Act, 1912 (Act VIII of 1912), a Notification regarding the protection of certain useful species of Wild Birds has been issued by the Governments of Bihar and Orissa and Madras, but I am not aware that any other Local Government has as yet issued a Notification under the Act.

Silk.—Six students completed a short course in Eri and Mulberry silkworm rearing. Besides these, Mr. Ayoob Ahmad of Mirpur, Azamgarh, Babu Shashi Bhusan of Shahabad and the Superintendent of Industries in Banganapalle State were given practical instruction in Sericulture and Silk-dyeing. Amongst the visitors were also the Consul for Italy and Rai Bahadur B. C. Basu, who had been deputed specially to inquire into Sericulture in

Assam, both of whom wished to acquire special information regarding silk-work.

A multivoltine mongrel race of mulberry silkworms was established after many trials, and this at first yielded silk superior in quality and quantity to those of the Bengal multivoltine races, but this strain unfortunately began to deteriorate after the fourteenth generation and in the sixteenth generation there was practically no difference between the mongrel race and the ordinary Bengal multivoltine races. Experiments are being continued to try and obtain a stable race. The univoltine mulberry silkworm eggs which were sent for cold storage to Ramgarh (Nainital) Muktesar and Calcutta, gave satisfactory results. Mulberry silkworm eggs were supplied to 157 rearers and eri eggs to 145 rearers, and mulberry seeds and cuttings to 14 applicants. Forty pounds-weight of eri cocoons were supplied to Messrs. Killick, Nixon & Co., of Bombay, for testing in the spinning mills in England. There is still difficulty in disposing of the small lots of eri cocoons which are offered for sale by small rearers. Silk exhibits were sent to Exhibitions held at Muzaffarpur and Monghyr, materials for exhibits were supplied to Mr. Audinarainswami, of Madras, who was awarded a gold medal for his exhibit, and materials for ten sets of silk exhibits were supplied to the Deputy Director of Agriculture, Bengal. Instruction was also given by correspondence in silk-dyeing, bleaching, silkworm rearing, spinning, reeling, and weaving. A Bulletin on Mulberry Silkworms and Silk was published during the year and a Bengali translation of this is now in the press, whilst another Bulletin on "How to improve Silk-reeling in Bengal" has been written and submitted for publication. A paper on Eri Silk was read at the All-India Industrial Conference held at Karachi in December 1913 and articles on Tasar and Mulberry Silkworm rearing were contributed to the vernacular magazines "Grihastha" (Calcutta) and "Krishi Sampada" (Dacca). Approximately Rs. 400 were credited to the

Treasury during the year, being sale proceeds of silk made at Pusa.

In Madras a fieldman has been employed on special duty on Sericulture in the Kollegal District; he has given practical instruction to the mulberry-silkworm rearers and a short vernacular leaflet with practical instructions for rearing has been prepared. In Bihar, the rearing of eri silkworms at Sabour was more successful during the year under report than in the previous season; eggs were distributed to a large number of zamindars and cultivators in the Bhagalpur District, but the usual difficulty was found regarding the disposal of cocoons by the rearers on a small scale. In the Central Provinces some univoltine seed, received from Italy in October 1913, began to hatch in December and the worms, which were reared from January to April, throve well and the resultant eggs have been kept in cold storage for the next season. In the United Provinces Mr. Akhtar Mohammad Khan has been on special duty at Shahjehanpur in connection with the eri silk work and in Assam Rai Bahadur B. C. Basu has been placed on Special Sericultural duty.

Lac.—During the two Lac seasons (October and June) at Pusa, upwards of 200 *Ber* trees were inoculated and the crop scraped, washed and sold. There were no students for either course and this is doubtless due to the fact that practical instructions have been given in the Bulletin on "The Cultivation of Lac in the Plains of India," of which the first edition of 1,500 copies was soon exhausted and a second revised edition was prepared and issued during the year; a Hindi edition is now in the press and an Urdu edition is in preparation. Brood-lac was supplied to twelve applicants and answers were sent by correspondence to numerous inquirers in various parts of India. The Superintendent of Industries in Banganapalle State spent a week at Pusa picking up details of the Lac work and was subsequently supplied with seed to commence work on an experimental scale. The services of Mr. C. S. Misra were also requisitioned by the Karauli State to start and supervise

Lac-culture in that State; he obtained *Kusumb* brood-lac from Rewah, selected the localities in Karauli where work was to be commenced and started inoculation of the trees selected. After doing this Mr. Misra visited Sind to obtain *Babul* brood-lac and to study the methods of propagation practised in that district. Collection of Lac specimens by the Forest Officers continued throughout the year, the series being, however, now completed for some districts; 42 parcels were sent out and 29 parcels were received.

In the provinces little lac-work seems to be done. In the Central Provinces the inoculation done in June 1912 proved unsuccessful and this was therefore repeated in October 1913, but the insects did not thrive well.

Bees.—At Pusa the last of the imported Italian queens died in July 1913. At that time there were two colonies headed by queens reared at Pusa and in August a third queen was reared and fertilized, but in the course of the year all the three queens failed and the bees died out. The proper fertilization of the queens seems to be at present the main difficulty in establishing these bees in the Plains; the workers seem to do well and it is comparatively easy to rear new queens as required, but these are usually snapped up by insectivorous birds during their marriage-flight or, if they survive this, fertilization does not seem to have been sufficiently thorough, as after a few months they commence to produce drone-brood only. Experiments have been continued with the Indian Bee (*Apis indica*) and a mill for preparing foundation-wax for this bee has been procured, as have also queen-excluders of special size, so that these bees can now be kept in bar-frame hives under modern conditions. A Bulletin on Bee-keeping has been prepared and submitted for publication. As Apiculture in the Plains is still in an experimental stage no regular course of instruction in Bee-keeping can be given, but Entomological Students and interested Visitors have been given such information as they required.

VI.—Miscellaneous.

The correspondence work of the Entomological Section continues to be very heavy and the numerous inquiries regarding insect pests, received from all over India, are dealt with as fully as possible. During the year 1,690 letters were issued and 1,385 received, but these numbers do not include a large mass of correspondence and papers dealt with demi-officially.

VII.—Insect Survey.

The collections continue in good order and numerous additions have been made by specimens collected during tours and those sent in by correspondents. Neuroptera were received back named from Mr. N. Banks, Ichneumonidæ from Mr. Morley, and Orthoptera named by the late W. F. Kirby. The Chalcididæ have been sent to Dr. L. O. Howard, of Washington, who has kindly consented to have them determined, and the Rutelidæ to Mr. G. Arrow for his "Fauna" volume on this group. The whole of the collections will be placed in one series, in order that the whole of the information available concerning any one species may be available in one place, and this work has been commenced.

VIII.—Programme of work for 1914-15.

This will follow generally in the lines of work of the current year as outlined in the present report, and will include general investigations of crop-pests, and especially of the pests of rice, sugarcane and cotton, of fruit-trees and of stored grain. A commencement has been made of collection of information for a general book on the crop-pests of India and progress in this will be continued, as also in the publication of information regarding life-histories of pests and coloured plates, of which a large number are now ready for printing. Work and experiments in silk, lac and bee-keeping will be continued, and

new insecticides and insecticidal methods tested as occasion arises. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

IX.—Publications.

The following publications have been actually published during the year under review :—

Entomological Memoirs.

Vol. V, No. 1. Life-histories of Butterflies, by C. C. Ghosh.

Bulletins.

No. 28. The Cultivation of Lac (Second, revised edition), by C. S. Misra.

No. 29. Eri Silk (Second edition).

No. 39. Instructions for rearing Mulberry Silkworms, by M. N. De.

Agricultural Journal of India.

October 1913. Red spider on Jute, by C. S. Misra.

January 1914. Some Experiments with Maize stored in Bins, by A. J. Grove.

REPORT OF THE IMPERIAL PATHOLOGICAL ENTOMOLOGIST.

(F. M. HOWLETT, B.A., F.E.S.)

I.—ADMINISTRATION.

I was in charge of the section for the whole of the period dealt with in this report. Mr. P. G. Patel was absent on privilege leave for one month and six days from April 14th, Mr. H. N. Sharma for two months and eight days from October 16th, and Mr. J. L. Mitter for two months from October 16th.

II.—EDUCATIONAL.

Messrs. C. S. Swaminath and J. L. Mitter appointed to Pusa by the Medical Research Association, finished their period of training here and have been taken over by the Medical Research authorities. Mr. Mitter has joined Major Mackie in Assam to assist in the Kala-azar investigation now in progress, while Mr. Swaminath is working with Colonel Adie in Kasauli at the transmission of *Halteridium* by flies of the genus *Lynchia.*

III.—RESEARCH.

My personal attention has been largely devoted to an attempt to work out methods of insect-control by examining and taking advantage of the reactions of insects to particular stimuli which seem to influence to a very large extent their more important activities. The lines on which one branch of this work is proceeding are indicated in an article on "The effect of oil of Citronella on two species of *Dacus*" (*Trans. Ent. Soc., London, 1912*, p. 417), and the results so far obtained encourage the hope that considerable improvements in our present methods may result from enquiry on these and similar lines, though these possibilities have hitherto been very largely neglected by entomologists.

Mr. S. K. Sen has been assisting me in the above enquiry and has also worked at the bionomics of mosquitos and particularly of mosquito-larvæ. The calomel method (see Annual Report, 1912-13) has given good results when used on a small scale in the field, and merits attention. Mr. Sen made a very careful investigation of the respiration of mosquitos in all stages, and has contributed an article on the subject to the *Indian Journal of Medical Research.* Publication of various articles by Mr. Patel and myself in the same journal has been suspended until a definite settlement of the question of " medical " work at Pusa. Mr. H. N. Sharma has also worked largely at mosquitos, and has attempted to get at the connexion between the existence of small wounds and abnormal feeding reactions. Mosquitos have been got to feed on red ink, salt solution, and other beverages, but no satisfactory explanation has been arrived at of a very curious fact.

In connexion with Major Holmes' Surra investigation, Mr. Grove, and subsequently Mr. Mitter, visited Kathgodam with the object of assisting the entomological side of the enquiry. This appears to be more complex than was originally supposed, and may necessitate the services of Mr. Patel or myself.

IV.—Veterinary.

In addition to the Surra investigation at Kathgodam and Muktesar, work on the bionomics of flies likely to be Surra carriers has continued. Mr. P. G. Patel made an extended tour in the Punjab with Colonel Newsom, and was able to give valuable assistance in the work on insect parasites. Mr. Patel has been also working with me on the habits and life-history of lice.

In the course of a tour in Madras I was able to dispel a long-standing supposition that Indian hides are seriously damaged by Warble-flies. These flies seem to be in fact rare in the plains, and an examination of damaged skins, chiefly sheep and goats, showed that the damage known in the trade as " warbles " is really due to the punctures conse-

quent on tick-bites. The rather similar damage called "pori-pori" may be due to the same cause, or possibly to lice, but it was not possible to settle this point definitely.

As Miss Ormerod states that over 40 per cent. of Indian hides are damaged by "warbles," it is as well to know that the injury is due to another cause.

Work is in progress on the egg-laying reactions of blood-sucking *Muscidæ*.

V.—Fruit-flies.

Mr. A. Mujtaba has visited Peshawar, the Central Provinces, and Bombay in the course of his work on this group, while Mr. Sen also visited Madras. The life-histories of two new species have been worked out, and a series of life-history memoirs of all the common species is now in course of preparation. The relations between the species and varieties, or local races, are evidently complex, and a complete knowledge and understanding of their bionomics can only come after a great deal of careful study. The spray method of control has proved successful and can be confidently recommended.

VI.—Miscellaneous.

In Mr. Grove's term of office as officiating Imperial Entomologist, I gave some assistance with the work on silk and silk weaving with which I was familiar, and in accordance with the recommendations and enquiries of silk merchants in Bombay and elsewhere made some modifications in our weaving practice in the direction of obtaining a more porous and absorbent cloth of a kind suitable for shirtings and the like. In this Mr. De has been successful.

I corresponded with the Chief of the Board of Health, Isthmian Canal Commission, with reference to Yellow Fever and *Stegomyia*. I forwarded to him two consignments of eggs of our common Indian *Stegomyia scutellaris* to be hatched out on arrival, in order to ascertain whether or not this species can convey Yellow Fever, a point possibly

of considerable importance to India. I have not yet heard the results of the trial.

Identifications of insects for medical officers and others has continued as usual, but presumably this work will be transferred at an early date to the official entomologist of the Medical Research Association.

VII.—Programme of work for 1914-15.

Research as indicated in para. 1, section III, above. It is hoped to complete a work on Indian Flies and blood-suckers based upon the sections written in "Indian Insect Life" on Diptera and other parasites of man and animals, but of a more detailed and somewhat less popular nature.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

(C. M. Hutchinson, B.A.)

I.—Administration and Tours.

I held charge of the section throughout the year excepting 14 days' privilege leave in February, when Mr. Walton was in charge.

Mr. Walton, Supernumerary Bacteriologist, has passed the vernacular examination prescribed for the Agricultural Department.

Assistants.—Mr. A. N. Bose was appointed to the vacant post of Assistant on Rs. 50—5—75 and Mr. N. P. Nandi to the fieldman's post in November 1913. On the transfer of Mr. N. C. Bose as a Bacteriological Assistant to the Sanitary Commissioner of Bengal, Mr. A. N. Bose was promoted to the post of Rs. 75—10—125 and Mr. H. D. Singh of the Chemical Section to the latter's post on 25th May 1914.

Mr. Vishwanadham, Second Assistant, was on privilege leave from 26th March 1914 to 25th April 1914. Mr. Rama Iyer, Third Assistant, was on privilege leave of one month and 29 days from 28th April 1914.

Tours.—To Dooriah to inspect manurial experiments.

To Poona, Bombay, Ahmedabad, Delhi, Calcutta and Shillong to visit various dairies in India.

To Dalsing Serai to see manurial experiments.

To Muzufferpore to see manurial experiments and to attend the meeting of the Bihar Planters' Association and to consult on use of seet.

To Sirseah to take over certain laboratory apparatus from there.

To Calcutta to consult Assistant Excise Commissioner, Bengal, Bihar and Orissa, and Assam, on Bákhar and "Pachwai," and to interview Scientific Officers of the

Indian Tea Association and Agents of various Tea Companies on the subject of green manuring, and to advise the Secretary, Ballygunge Cricket Club, on the subject of renovating turf.

To Bara-Chakia to obtain samples of Filter Press Mud and information as to amount available for use as manure.

The Supernumerary Agricultural Bacteriologist went also on tour to Bangalore in connection with examination of soils for *Azotobacter* and also to Darjeeling to attend the Cattle show and to ascertain the dairy conditions in the Darjeeling District.

II.—TRAINING.

Mr. Barkat Ali, Assistant to the Agricultural Chemist to the Government of the Punjab, continued his course of training in Soil Bacteriology, specializing in examination of "Reh" soils from the Punjab. He will complete the two years' course in August.

Mr. D. V. Bal, Assistant to the Agricultural Chemist to the Government of the Central Provinces, is undergoing a revisionary course of chemical analysis in the Chemical Section preliminary to taking a course in Soil Bacteriology in this section.

III.—SOIL BACTERIOLOGY.

The principal subject upon which work has been done in this section during the past year has been the use of green manuring, with special reference to the addition of nitrogen to the soil by this means and the availability or otherwise of this element when so added. The scheme of experiment as originally designed was intended to extend over a period of three successive seasons; *interim* annual reports were to be issued in the form of Bulletins, the final report to appear as a Memoir embodying the results and conclusions from the whole period. The first season's results were published as a bulletin and those of the second year are ready for publication in the same form; it appears doubtful whether it will be advisable to conclude the experiments with those of the current or third year as it is abun-

dantly evident that the information so far obtained forms but a small fraction of what may be derived from further study of the subject it is also necessary to state that owing to untoward circumstances the quantitative value of the field experiments of the first two seasons was greatly diminished, which makes it necessary to repeat the more important ones. The difficulty of obtaining an area of even soil for experimental plots was well illustrated in the first year, when it was found necessary to discard the whole of one series on account of obvious initial differences between the soils of various plots; in the second year a carefully selected area taken in the middle of a large field proved its unsuitability for anything more than comparisons between adjacent plots owing to waterlogging of portions consequent on heavy rain and inadequate drainage. During the current year (1914) a fresh site has been selected which is free from such inequalities, but again difficulty has been experienced owing to irregular rainfall in June at the time of sowing and the attacks of caterpillars upon the backward plant; the latter has, however, survived, and although the six weeks old crop weighs less than two-thirds of that of the same age in previous years it is hoped that reliable comparative results will be obtained. In addition to these field experiments on the farm an area of one acre has been fenced in, cultivated, and sown with *sanai*, on the south side of the new outside laboratory, and it is hoped that experimental plots on this area laid out in triplicate divisions of $\frac{1}{24}$th acre each will help to provide controls for the field experiments carried out on a larger scale on the farm. In my previous Annual Report it was mentioned that the green manuring experiments for 1913-14 would include a trial of the use of the method of fermenting the green crop before applying it to the land, and at the same time concentrating the manurial action by restricting the treated area although using the whole of the fermented material. The result when such concentration was carried out, the fermented *sanai* being returned to about half the area on which it had been grown, in the case of the following *rabi* crop of wheat

was very apparent as a marked increase in crop, but owing to the waterlogging of part of the area and the consequent interference with the regularity of the series, definite quantitative conclusions could not be drawn as to the relative value of this method.

Small plots in the compound of the outside laboratory of about $\frac{1}{50}$th acre area were used for qualitative experiments in green manuring, the *rabi* crop being oats; variations in the method of preparing the fermented manure were tested and showed decided differences which are described in the report on the subject for 1913-14 now in hand. It was also found that for this crop on light soil no apparent advantage was obtained by concentration of the manure, improvement of the crop being probably due to the comparatively high availability of the nitrogen content of the fermented material. Further experiments dealing with the application of the method to other crops such as tobacco are in progress during the current season.

In connection with this work a considerable amount of research has been carried out in the laboratory in continuation of that of last year which dealt mainly with the ammonification and nitrification of the buried green crop: further observations on these two points have been made and in addition some fourteen species of bacteria apparently closely connected with the decomposition of buried Sann hemp have been isolated, and their physiological and morphological characters studied. It is remarkable that no one species of bacterium capable of attacking cellulose has been found so far in the general soil complex although the symbiotic relationship of two or more has been shown to produce this result; the opinion expressed in the Bulletin on green manuring published in 1914 that soil fungi probably played an important part in the breaking down of cellular tissue is strengthened by further observation; it is hoped that work on soil fungi by the Mycological Section of this institute may furnish valuable information on this point.

Part of the study of the decomposition of green manure in the soil involved investigation as to the relative rates of formation of humus and nitrate; this enquiry has not yet arrived at the conclusive stage suitable for report.

A considerable amount of work was done in connection with the changes taking place in fermenting green manure; the manurial value of this material appears to be due to the rapid formation of simple nitrogen compounds such as ammonia, from the proteid content; the nitrification of this ammonia, however, is interfered with by the fact of its concentration and also by the presence of soluble organic substances some of which at least are strongly toxic to nitrifying bacteria and in less measure to others; this condition persists so long as the water extract remains acid to litmus which under ordinary conditions of manufacture might extend to as much as six weeks, and renders it necessary to study the conditions under which such manure can safely be applied to arable or other soil. The mode of preparation may also be varied considerably with corresponding differences in manurial action; such differences are apparently correlated with the rate at which the nitrogen content becomes available and are of importance in field practice with reference to the time of application, the nature of the soil, and the nitrogen requirements of the crop intended to benefit by the use of this form of manure.

It is interesting to note that the rapid ammonification which takes place when green manure is placed in water and allowed to ferment was found to be accompanied by the development of large numbers of ciliates, flagellates and amœbœ, whose presence does not appear in this instance to be prejudicial to the activity of ammonifying bacteria; it may be conjectured that under such conditions as obtain in this case the abundance of organic food would produce a rate of reproduction amongst the bacteria which would more than counterbalance any phagocytic action on the part of the protozoa.

The conditions under which nitrification takes place in soil have naturally formed an important part of the work

of this section during this as in previous years; it was found in connection with numerous experiments made to determine the optimum moisture content for nitrification in various soils, that not only is the amount of water all-important, but that the greatest amount of nitrification obtainable depends upon treatment which takes into account the fact that ammonification is the necessary antecedent to nitrification in the case of organic matter, that this process is furthered by a high percentage of moisture, that high concentrations of ammonia inhibit nitrification, but that such ammonia is absorbed by the soil and can then be nitrified. Experiment showed that the most rapid and complete nitrification of any given quantity of nitrogenous organic matter could be effected in soil by producing anærobic conditions with water saturation and subsequently draining and aerating; the rapidity with which nitrification takes place under these conditions depends upon the relative completeness of the anærobic and subsequently of the ærobic conditions. This was the case in all the soils experimented with but may not of course be of universal application. It was found that much more rapid ammonification took place in the case of organic matter kept under anærobic conditions in soil than when free aeration was allowed, whether such anærobic conditions were produced by water saturation, or replacement of air by nitrogen or carbon dioxide or simply by tightly closing the vessel containing the soil. At the same time toxins were produced which not only inhibited nitrification before the ammonia concentration was sufficient to do so, but afforded water extracts which were toxic to seedlings and to bacteria; subsequent aeration removes this toxic condition and the formation of nitrates takes place, the ultimate result being a high percentage of nitrification of the nitrogen of the organic matter; this apparently represents the cycle of changes in the case of the fermentation of green manure described above; its application to field practice is now being studied.

In connection with the nitrification of green manure it was found that a loss of nitrate invariably occurred between

the 8th and 12th weeks of the process in the laboratory; a considerable amount of work has been done with the object of discovering whether this loss could be accounted for by correlating it with the gradual evaporation of soil water; the enquiry is not yet sufficiently complete for conclusive report, but it seems certain that the change noted is due to variation in the water content of the soil rather than to seasonal variation in the functions of the soil flora.

Experiments were made to determine the effect upon nitrification of varying the quantity of nitrogen as organic matter added to the soil; it was considered probable that any excess above the optimum would retard or even inhibit nitrification, but that the optimum might vary considerably with different soils, and also in the same soil under different conditions. An unexpectedly high optimum was found for mustard cake in Pusa soil, namely, one per cent. of the soil weight, but it was shown that the high lime content of this soil was mainly responsible for this high figure, and that in soils such as the average tea soils of Assam, with less than one per cent. of lime, a much smaller quantity of cake would fail to nitrify at the normal rate. A study was made of the progress of decomposition of cake in soils varying in lime content, by periodic estimations of the loss on ignition, humus, ammonia and nitrates; it was found that decomposition was rapid in proportion to high lime content, although in time the soil lower in lime attained the same nitrate concentration.

Isolation of nitrifying organisms from Indian soils was continued with special reference to a nitrite forming organism hitherto undescribed, the isolation of which by Mr. Joshi, 1st Assistant, is still in hand.

Azotobacter.—A number of soils was examined for *Azotobacter*, which was found in those from Naupada, Vizianagram, Waltair, Tuni, Samalkota, Ellore, Walajah Road, Bowringpet, Jalarpet, Bangalore, Darjeeling and Cawnpore.

A series of determinations of amounts of nitrogen fixed in liquid culture media inoculated with Pusa soil week by

week, and which is still in progress, shows small irregular variations. The amounts are of the same order as those obtained by Ashby at Rothamsted and by Sackett in Colorado.

Pure Cultures.—The amount of nitrogen fixed by pure cultures of *Azotobacter* isolated from Pusa soil was increased by the additions of basic slag or humus to the ordinary medium but was diminished by the substitution of magnesium carbonate for calcium carbonate. The amounts of nitrogen fixed in the pure cultures are similar to those obtained by other investigators in Europe and America.

Well marked differences were observed in the morphological and cultural characters of species of *Azotobacter* isolated from Pusa, Cawnpore, Darjeeling and Bangalore soils, and the amounts of nitrogen fixed by these also varied.

A few preliminary experiments on nitrogen fixation in the soil were carried out.

The addition of a seer of cane sugar to a plot two square yards in area, resulted in an increase, in the nitrogen content of the first six inches of soil, of nearly fifteen per cent. in 10 weeks.

The stimulation of nitrogen activity by the addition of soluble carbohydrates may possibly be of considerable practical importance in the future. It has been shown by Koch that certain bacteria can form soluble carbohydrates from cellulose which can be used by *Azotobacter* as a source of energy for nitrogen fixation; this action would bring the organic matter content of the soil into immediate relation with its possible gain of nitrogen from the air.

Some interesting results were obtained in connection with work on bacterio-toxins in soil; it was found possible to measure the relative toxicity of various bacterial species to an intermediate form (*B. prodigiosus*) and to one another, by use of plate cultures and the measurement of the rate of CO_2 formation in solid and liquid media, and the effect upon the latter of the antagonism or symbiotic action as

the case might be. Marked instances of antagonism and symbiosis were found, and the production of toxins was demonstrated; the methods in use might perhaps be employed to advantage in connection with the investigation of the physiological functions of pathogenic organisms.

Some further work on bacterio-toxins in soils was carried out in connection with the sewage-treated soil samples sent for examination by Mr. Allen of Nagpur. Work on these soils was discontinued at the request of Mr. Allen as the sewage treatment scheme on the Nagpur experimental farm is not yet in complete working order.

IV.—Special Enquiries.

Potato Rot.—The enquiry on this subject referred to in my previous report is not yet complete, but has been continued throughout the year in order to gain further and fuller information upon various points in connection with the physiological functions of the organisms involved, and the probable distribution of the latter in soil or elsewhere; this information is necessary in order to frame effective preventive measures; reports of the occurrence of tuber rot in store continue to arrive from various parts of India, and numerous samples have been examined, in many instances the rot is due to fungal and not to bacterial attack, as described by the Imperial Mycologist. A report will be issued shortly.

Bákhar.—At the request of the Assistant Commissioner of Excise for Bengal, Bihar and Orissa, and Assam I undertook to investigate the biological factors in connection with the fermentation of rice beer, with a view to determine the feasibility of controlling the manufacture of the ferment, which is at present in the hands of a peculiarly unsuitable class, generally hillmen, who make the ferment or Bákhar according to time-honoured traditional methods of more antiquity than precision. The result of the present state of affairs is a great variation in the quality of the fermented liquor, due to the presence in the Bákhar of

numerous species of ferments, and in the rice beer itself there may be deleterious substances derived from the same source. It is thought that the manufacture of the Bákhar or yeast might with advantage be controlled in order to provide brewers with a reliable ferment of uniform composition and action, and examination of samples of this material from various sources shows that the fermenting organisms present differ widely in character and effect.

The fermentation of rice differs from that of barley in one important respect, in that the rice as a consequence of husking loses its power of germination, and with it is also lost the natural change from starch to sugar produced by the enzymes formed during this process; this change in the case of barley is characteristic of the operation known as malting, which results in the change of the starch of the grain into sugar, a necessary antecedent to fermentation by yeast. In the case of rice it is therefore necessary to produce the change of starch into sugar known as saccharification, by the addition of some form of saccharifying ferment which will provide the enzyme diastase by which this change may be brought about. Barley grain on germination produces diastase which under suitable conditions converts the starch of the grain into sugar, the grain thus altered in composition being known as malt; the same result is obtained with rice by the addition of Bákhar which contains various fungi or moulds whose natural growth on a starchy medium is accompanied by the secretion of diastase. The efficiency of a sample of Bákhar (which is made up and sold in the form of small greyish white cakes of about one ounce in weight) will therefore depend firstly upon its containing an efficient diastase-producing fungus, and examination has shown that the samples collected from various sources differ widely in respect to the kinds of fungi present and their correlated diastasic power with regard to rice starch. When the Bákhar cake is powdered and mixed with rice which has been prepared by moistening, the fungi present form mycelial growth which involves the rice grains and gradually converts their starch into

sugar, the completeness of this result depending upon the suitability of the conditions provided and upon the presence of fungi of adequate diastasic power. A large number of different species of fungi were found in various samples of Bákhar and the rapidity and completeness of the saccharification of the rice starch also varied in accordance with their relative diastasic powers, which were measured in pure cultures. It may be said that no one of the numerous species found compared favourably in this respect with *Aspergillus Oryzæ* which is the organism used for this purpose in Japan in the manufacture of "Sake" or rice beer, by the use of the corresponding preparation to Bákhar known in Japan as "Koji;" it is possible that the introduction of *Aspergillus Oryzæ* into India might considerably improve the rice beer of this country.

When by the action of the diastase-producing fungi a large proportion of the starch of the rice grain has been converted into sugar, mostly maltose, the next step is the fermentation of the sugar by yeast with formation of alcohol. In the very full and interesting account of the use of Bákhar by J. C. Ray published in the *Journal of the Asiatic Society of Bengal* (Vol. II, No. 4 of 1906) the author ascribes this alcoholic fermentation to the mucors which have already exerted a saccharifying influence on the starch; I have never failed, however, to find yeasts present in Bákhar capable themselves of producing alcohol without involving the supposition put forward that mucors in their vegetative condition secrete diastase but in the reproductive stage produce zymase, the alcohol producing ferment. The yeasts found varied just as the mucors and other fungi were found to do, and as it is a well known principle in brewing and distilling that the variations in physiological characters of the yeasts involved require careful selection of the latter and exclusion of undesirable varieties, it is very probable that the haphazard introduction of unknown numbers of kinds of yeast into rice beer by the agency of Bákhar would afford another point over which control might usefully be exercised.

A third point arises in connection with the use of Bákhar; as will readily be understood, when any organic matter such as moist rice is exposed to the air the ensuing fermentation is likely to be complicated by the presence and activity of bacteria; in the case of beer brewed in Europe from barley-malt and hops, the value of the latter depends upon their content of lupulin with its associated "hop resins" which act as preventives of bacterial action; Bákhar contains many substances the inclusion of which probably originated in an attempt to prevent putrefactive changes, although now they form merely parts of the tradition or trade secret handed down without knowledge of their specific function, or of the fact that whilst the mouldiness aimed at is produced by fungi, the putrefaction sometimes resulting is due to bacteria.

Chillies, ginger, and the bark and roots of various plants are among the substances incorporated with the ground rice to form Bákhar cakes; so far the function of the various substances examined appears to be to restrict the growth of bacteria during the earliest stages of infection of the rice to be fermented until the growth of the mucors has become strong enough to suppress bacterial competition, and in this respect they resemble the hop resins in action.

Many of the substances added to Bákhar by the makers are no doubt intended to produce other effects which would, however, be confined for the most part to the beer and would not appear in the distilled spirit; it has been reported that *Datura* and *Nux Vomica* are sometimes used in this way and it is natural to suppose that the reputation of a Bákhar maker might be enhanced amongst a certain class of his clients by such reprehensible practices. Specimens of a plant said to be a necessary ingredient of Bákhar as made in the Darjeeling district, have been sent to me for examination; this plant is known to the Limboo tribes as "Wadinghangma" and to the Nepalese as "Bhimsen pati;" it has been identified by the curator of the Lloyd Botanic Garden in Darjeeling as

Polygala arillata; the bark of the roots afforded a decoction, the antiseptic properties of which are now under examination.

Biological Analysis of Soils.—

Reh Soils.—Samples of "Reh" soil received from the Agricultural Chemist to the Government of the Punjab were under biological examination and formed a subject of study for Mr. Barkat Ali, a student from the Punjab who is undergoing training in soil bacteriology in this section. Several interesting facts were discovered as to the effect of lixiviation upon the flora of these soils, and the conclusion was arrived at that the normal processes of ammonification, nitrification and nitrogen fixation would be the natural consequence of removal of the excess of salts from the soil by this means; Mr. Barkat Ali has furnished an excellent report upon his work which encourages the belief that a well trained chemist can acquire sufficient knowledge of the methods of biological analysis as practised in this laboratory to enable him to carry out such work satisfactorily without excessive supervision after a two years' course of instruction.

Biological analyses of soils from Cawnpore, Sind, Assam and Nepal were carried out and reports upon them furnished; the method used is still under revision owing to the necessity for variation in accordance with the character of the soil and the information desired.

V.—Programme of work for 1914-15.

Major Subjects.

(1) Nitrification.

(2) Nitrogen fixation.

(3) Biological Analysis of soils.

(4) Investigation of effects of management upon the constitution of the Soil Complex.

(5) Green Manure experiments.

Minor Enquiries.

Potato Rot and other Plant Pathogens.
Bacterio toxins in Soils.

VI.—Publications.

Acting in conjunction with the Imperial Agriculturist I made a series of tours as detailed above with the purpose of investigating the conditions under which dairying is being carried on in India at the present time, and furnished a report dealing with this subject. (Published as appendix F to the Proceedings of the Board of Agriculture in India held at Coimbatore on the 8th December 1913 and the following days.)

A Bulletin on Green manuring (Pusa Bulletin No. 40) recording the experimental results of the first season's work on this subject was published.

REPORT OF THE IMPERIAL COTTON SPECIALIST.

(G. A. Gammie, F.L.S.)

I.—Charge and Tours.

I held charge of the appointment throughout the year.

Tours.—In July, I visited Simla to assist the Officiating Agricultural Adviser to the Government of India in drawing up a note on the present position of cotton in India; in October I visited the Punjab to advise the Director of Agriculture in consultation with some members of his staff, as regards the present and future lines of work to be undertaken in cotton; in the same month I also visited the United Provinces, where I met Dr. Parr and Mr. Wilson, the Officiating Economic Botanist. In November I visited Sind, in the company of the Director of Agriculture, Bombay, to discuss certain details in cotton cultivation in Sind; in March 1914 I visited the agricultural stations in Guzerat, including Baroda, and the Southern Mahratta Country. The remainder of the time during the year was devoted to the supervision of my own experimental area, to the giving of advice to many correspondents and to arrangements connected with the valuation of numerous samples forwarded for my opinion.

My assistant, Mr. D. P. Mankad, made several tours in Guzerat, Kathiawar, and the Southern Mahratta Country throughout the year.

II.—Cotton in the Provinces.

Punjab.—After my visits of inspection I furnished the following short note to the Director :—

" There are three distinct types of American cottons, (*a*) Upland Georgian, (*b*) New Orleans and (*c*) annual form of soft Peruvian. The first, on account of its hardiness and immunity from the attacks of pests, is obviously the

type which should be introduced into general cultivation; the second is less hardy in its nature. It is attacked by Jassids this year and its superiority to Upland is so trifling that it is not worth the risk of being maintained. The soft Peruvian is one of the finest cottons ever grown in India. Its low outturn (in spite of its higher price), however, brings it on a par with Upland. This variety should not be distributed indiscriminately, but should be brought to the notice of farmers of good position who would undertake to give it the necessary care and attention. I would advise that your selections of American cottons be kept down in number. Many at present existing do not differ sufficiently from one another to deserve being kept separate.

"As regards the *Deshi* cottons, a survey should be carried out in each tract so that the dominant forms in each can be extracted and tested comparatively as pure types. Those passing the test could be rapidly multiplied on seed farms for distribution to cultivators. It is almost unnecessary to point out that aid should be given in the marketing of the produce until the trade is disposed to pay fair prices spontaneously.

"Mr. Milne's discovery that root-rot is caused by a nematode worm is most interesting and I hope he will publish his notes as soon as possible. He has now on his Botanical area pure strains of all the varieties of cotton found in the Punjab. These can be compared with your survey types and time could be saved by making a start from these for your seed farms."

Since writing the above I have heard that the cottons of the districts of Lyallpur, Hissar and Lahore have been surveyed with the following results:—

Lyallpur Tahsil.—*Gossypium indicum*, yellow flowered, is the prominent form.

Toba Tek Singh.—*Gossypium sanguineum*, both broad-lobed and narrow-lobed, chiefly near Gojra, and *Gossypium indicum*, yellow flowered, in almost as great quantity.

Sumundri and Jaranwala.—*Gossypium indicum*, yellow flowered, and *Gossypium neglectum*, yellow flowered, in almost equal quantities.

There is everywhere a fairly considerable admixture of the white flowered varieties of *Gossypium indicum* and *neglectum*, and these, popular opinion regards as heavier yielding. Certainly the percentage of lint is higher in the white flowered varieties grown in the Lyallpur Station. *Gossypium sanguineum* is not uncommon in the Lyallpur and Sumundri Tahsils, but it is the predominant type in few villages.

Hissar.—In Hissar, Hansi and Fatehabad Tahsils two-fifths are yellow flowered *Gossypium indicum* and one-fourth to one-third is white flowered *neglectum*. There is no *Gossypium sanguineum*. Cotton is unimportant in Bhiwani and Sirsa Tahsils.

Lahore.—Yellow flowered *Indicum* represents 74 per cent. in Chuman, 78 per cent. in Kasur and 91 per cent. in Lahore Tahsil. In Chuman about 10 per cent. is yellow flowered *Gossypium neglectum*, in Kasur there is a good deal of broad leaved *Gossypium sanguineum* in canal-irrigated villages.

As regards the retention or rejection of American varieties, those retained are of the rough leaved and those thrown out are of the smooth leaved type. 4 F is the chief American cotton on the Station and it has done well everywhere in 1913. The experience of past years shows that American cottons will do well in the colonies under canal irrigation, but they require good land and better cultivation than the indigenous cotton.

United Provinces of Agra and Oudh.—In connection with my tour in these provinces I supplied the following short note :—

" The lines of work in Dr. Parr's division are :—

(1) The substitution of the prevailing mixture by the

distribution of the seed of a productive white flowered indigenous cotton. The colour of the flower is of important assistance in maintaining the purity of the type. There are now 20,000 acres of this under cultivation and it may cover the whole cotton area of the division in the course of a very few years. The whole of the seed cotton is ginned under the personal supervision of Dr. Parr, so that the chance of mixture is avoided.

The introduction of this variety teaches the cultivator the value of a pure crop and after he has learned his first lesson a second could be commenced by issuing one of the higher class yellow flowered types, of which one at least shows great promise here.

(2) Regarding the comparative merits of Cawnpore-American and *Bhuri*, Dr. Parr considers that the latter will be more profitable and I am disposed to agree with him. Mr. Burt is, however, of a contrary opinion and the difference can only be settled by making comparative tests.

Previous experience with the Cawnpore-American certainly pointed to the fact that the outturn of American cotton in the United Provinces tends to diminish more and more every year.

(3) Cambodia, on account of its prolonged season of growth, is not at all promising and its cultivation should be given up.

(4) The problems to be solved in the United Provinces are simple, one being the introduction of a longer stapled sort (either American Upland or an Indian hybrid as Mr. Leake is attempting), the other being the substitution of a good-paying pure *Deshi* crop in the place of the mixture, which is now universally grown."

In acknowledging the valuations of samples of cotton which were sent to him, Mr. Burt gave me the following interesting information :—

"The results of spinning trials at the Elgin Mills and of a valuation by the British Cotton Growing Association show that the Cawnpore-American is valued more highly than the Dharwar American. This difference is, however, not important as the Dharwar variety does not do so well here as regards yield and is much inferior to the Cawnpore variety in ginning percentage. From the valuation based on larger samples I am inclined to think that the Cawnpore-American is more nearly equal to Middling American than Messrs. Tata and Sons' valuation.

"As regards Boyd and Black Rattler, I am rather surprised to find that Boyd is valued so much above Cawnpore-American, as there was little difference as far as we could tell here. Boyd is, however, one of the most promising of the imported varieties and ginned well. As regards the Black Rattler, it is impossible to say as yet whether this will yield sufficiently well to be worth growing here. It is a later plant than the Cawnpore-American, but has not yet been fully acclimatized. In the meantime we are continuing trials of these and other cottons and at the same time trying to select uniform agricultural types from them. The Cawnpore-American variety yielded well last year on a considerable scale and we have about 500 to 600 acres of this variety this year, having received a guarantee of a minimum price of $6\frac{1}{2}$ per lb. for the lint *plus* premium depending on the spot price of middling American."

During the cropping season I deputed Mr. Mankad to Kathiawar to assist the Assistant of the Economic Botanist, United Provinces, to select types of Kathiawar cottons for experimental purposes at Cawnpore.

Central Provinces.—From valuations made on a set of samples, with details of acreage, outturn and percentage of cotton to seed, supplied by the Akola Experiment Station the varieties grown in Berar fell into the following order

of merit placed by the market value of the clean cotton alone :—

	Rs.	
(1) Gossypium neglectum, *var.* Rosea .	60	per acre.
(2) Gossypium neglectum, *var.* Cutchica .	58·5	,,
(3) Gossypium hirsutum, *var.* Bhuri .	53·75	,,
(4) Gossypium neglectum, *var.* Vera .	51·5	,,
(5) Gossypium neglectum, *var.* Vera (Berar Jari)	45·5	,,
(6) Gossypium indicum (Bani) . . .	41·4	,,
(7) Gossypium neglectum, *var.* Saugor Jari	41·12	,,
(8) Gossypium neglectum, *var.* Malvensis	40·5	,,

This proves that the cultivators are abundantly justified in their selection of white flowered cottons (of which the two chief head the list), for profit, *Bhuri* follows closely in value and the remaining yellow flowered indigenous cottons fall appreciably in the rear. *Saugor Jari* has solid qualities for its own tract but it cannot compete with the natural denizens of the real cotton soil.

Madras.—A parcel of Cambodia cotton grown at the Hagari Station was the only material submitted to me for opinion during the year. The outturn of *kapas* was 631 lbs. per acre and the ginning percentage was 37·5. In the Bombay market the cotton was valued at Rs. 295, Madras Cambodia of the day standing at Rs. 315. The value of the cotton alone was therefore Rs. 89 per acre, a very satisfactory result.

Bombay.—Sholapur District.—Seed of Gossypium neglectum, *var.* rosea, was supplied to the Inspector of Agriculture, Sholapur, at the request of the Deputy Director of Agriculture, Southern Division. It was tried at Barsi, where the crop suffered much from want of rain, and at Sholapur, where the crop was very vigorous, perhaps owing to the fact that it was irrigated four times. At Barsi the outturn of seed cotton per acre was 364 lbs. and at Sholapur 1,510 lbs.

Manjri Station.—At this station experiments, with the view of introducing some paying sort of cotton into the

sugarcane tracts are still persevered with and I made an inspection and reported as follows :—

"I do not consider that there is any hope of success in any of the *neglectum* varieties under irrigation. Broach has already been tried and the results were very unsatisfactory.

"*Cambodia* seems to be the only good cotton so far that thrives under irrigation and it seems to do well round Poona where conditions are favourable. At Manjri, you have tested it under irrigation for the first time. It has received four waterings which are quite sufficient. As regards spacing, we agree that the best distance is 3 feet between rows and one foot apart in the lines. As to time of sowing, I would advise it to be done as soon as the soil is moist enough after the first rains."

The total yield per acre was 347 lbs. of seed cotton and the percentage of cotton to seed 40·3. Messrs. Tata, Sons & Co. reported as follows on a sample sent to them for opinion :—"It has lost in length of staple and is also weak. It shows deterioration. The value is Rs. 265 per candy against Rs. 310 for Madras Cambodia."

The value of the cotton produced is only Rs. 47 per acre. The result is discouraging, but I have advised a repetition of the trial.

Agricultural College Farm, Poona.—Although this is not within the cotton tracts, a number of experiments on cotton were conducted under very favourable conditions.

Fourteen small plots of *rosea* were treated with varying mixtures of farm-yard and artificial manures: the control plots being unmanured or treated with farm-yard manure alone.

Messrs. Tata, Sons & Co. reported as follows on the 14 samples submitted to them :—

"These are almost all alike with the exception of Nos. 1, 7 and 11, which are a little better than the others. Compared with type 23 (Khandesh from Dhulia), they show no improvement, they are a little inferior in length of staple and all

have rough feel. Value of 1, 7 and 11 Rs. 202 each, the rest, Rs. 200 (Fully Good Khandesh standing at Rs. 205)."

This experiment must be continued for a few years before any definite observations can be deduced.

Bhuri was reported on as having long staple but weak fibre.

The fibre of *Cambodia* was found to be very weak.

Of three sets of *rosea*, the first with the seed separated by gravity produced a crop which was found to be better in staple and soft in feel and was valued at Rs. 215; of the second, with seed not separated, the cotton was a little inferior and was valued at Rs. 210. The third from Akola seed was rough in feel and short in staple and was valued at Rs. 205. In this instance, there was a decided advantage gained by separation of the seed before sowing.

The white flowered narrow lobed variety from selections was valued at Rs. 202 equal to that of Nos. 1 to 14, which are of the same type.

Broad lobed variety from selections of *Malvensis* was valued at Rs. 237 against Rs. 235 from seed from Akola.

In Khandesh variety of which fresh seed was received from Dhulia and grown here, the cotton was deteriorated, the staple was very short and resembled Bengal cotton more than Khandesh. Value Rs. 205 (Fine Khandesh standing at Rs. 215).

Karkheli had deteriorated somewhat, valued at Rs. 265 against Fully Good Karkheli at Rs. 275. White flowered broad lobed (*Cutchica*), farm seed, resembles Fine Bengal, valued at the same rate, *viz.*, Rs. 205.

Of the four plant-to-plant selections of yellow flowered broad lobed, *neglectum* type, No. 2 comes first at Rs. 242, No. 4, second, at Rs. 240, No. 3, third, at Rs. 238, and No. 1, fourth, at Rs. 235 (Fine Khandesh of the same date at Rs. 215).

Of the two yellow flowered narrow lobed *neglectum* plant-to-plant selections, one is valued at Rs. 235, the other at Rs. 237.

Of four white flowered broad lobed *neglectum* and three white flowered narrow lobed *neglectum* plant-to-plant selections, one only was valued at Rs. 215 equal to Fine Khandesh; the rest at Rs. 212, equal to Bengal cotton, Rajputana style.

An analysis of the outturns per acre of eight varieties shows that they stand in the following order of their value :—

Serial No.	Name of variety.	Value of outturn per acre of cotton.
		Rs
1	White flowered broad lobed *Neglectum* (*Cutchica*) .	112·5
2	Khandesh Local	107·1
3	Rosea (*Varhadi*)	95·16
4	Buri	93·66
5	Yellow flowered narrow lobed (*Vera*) . . .	78·87
6	Yellow flowered broad lobed (*Malvensis*) . .	59·81
7	Karkheli (*Indicum*)	53·68
8	Cambodia	34·89

The white flowered varieties of cottons, as usual, have been proved to be the most profitable. It has also been proved in the Deccan that the duration of these plants is far longer than either in Berar or Khandesh and that the production of cotton also persists over a longer period.

Guzerat.—I supplied the following notes after the inspection of the cottons on the experimental stations in the province :—

" Surat.—I consider that Selection IA and Selection II are the varieties that should be persevered with, because, of both, the outturn and ginning percentage are above the figures of the local cottons and even above those of the improved crosses already distributed. If the samples of these varieties are submitted to me for valuation, I shall have them thoroughly examined.

" Mr. Bhimbhai informs me that, last year, of No. 1018-P. G., selected Broach, 10,000 acres were sown in British territory and 7,000 acres in Baroda. The Syndicate secured 5,000 bales out of the total of 7,000, the remainder was sold independently by the cultivators to other merchants when the Syndicate ceased buying. This year, 7,000 acres have been put out and one merchant, Mr. Motibhai Raghawji of Surat, is offering Rs. 5 for 960 lbs. of seed cotton over market rate. The Agent of Messrs. Whittle & Co. at Bardoli is also satisfied with the result and they are paying Rs. 4 above the market rate. There is a strong probability that these selected varieties will be maintained by the cultivators, in spite of the withdrawal of the Syndicate's offer.

" Mr. Bhimbhai considers that it will be quite practicable in villages which grow blocks of these selected cottons to form Committees to settle the disposal of the produce without the intervention of middlemen. The new varieties are maintaining the improvement in the ginning percentage.

" Selection IA, out of selected Broach, gives 35·5 or nearly 3 per cent. over the local variety. In the quantity and quality selections No. 2 out of selected Broach, the quality is good and the ginning percentage is 34. This year, it is expected to also stand highest in yield.

" *Cambodia* is abandoned as being unsuitable for the black soil.

" Nadiad.—Cambodia cotton is being attacked by wilt and also by aphides this season. The percentage has fallen to 31. In appearance its lint is much the same as that of *Lalio*, which, being indigenous to the tract, is not so liable to be influenced by abnormal seasons. In the district there is a difficulty in the marketing of the produce, but as many of the cultivators are making their own arrangements for the importation of the seed, the final disposal of the crop should remain in their own hands.

" The cotton crosses on the farm show so very little promise that it would be well perhaps if the officers concerned

drop them and concentrate their attention on the improvement of *Cambodia* and *Lalio*. The increase in the percentage of cotton to seed is the point to be aimed at in the former and the high yielding capacity in the latter is desirable. In my own opinion, *Lalio* will prove to be the cotton most suitable for the tract. During next season *Bhuri*, *Cambodia* and *Lalio* are again to be tested.

"The Superintendent of the Nadiad Farm says that *Cambodia* has been grown on a fairly large scale by cultivators, who now find a difficulty in the disposal of the produce, of which the total amount is still so small that the ginning factories do not care to make any special arrangement for it. If the cultivation extends, assistance ought to be furnished to them from the Department. The cultivators find that the crop is inclined to mature late and they still maintain an open mind regarding the comparative merits of *Cambodia* and *Lalio*."

The following valuations of samples of Guzerat cottons were kindly supplied by Messrs. Tata, Sons & Co. :—

Surat Farm.

Serial No.	Name of sample.	REMARKS.
1	Selection IA selected .	Compared with No. 7 (Surti-Broach), No. 1 (Surat selected) is decidedly longer and stronger in fibre and besides the fibre is even. It can be compared with best Surat except in softness, the feel being rather coarse. Value Rs. 320.
2	Selection IA General .	Fibres rather uneven. Length also shorter than No. 1. Value Rs. 310.
3	1018 P G General .	In all respects same as No. 1. In feel it is little softer, rather uneven in fibre, but may be a little bit longer. Value Rs. 320.
4	1027 ALF II selected .	This is very long stapled strong fibred cotton and deserves to be encouraged. It is almost equal to Navasari cotton both in length and strength, and though acclimatized for a number of years, it has in no way deteriorated. Value Rs. 335.
5	Do. General .	Almost same as No. 4, but variable in length of fibre. Value Rs. 320.

Surat Farm—contd.

Serial No.	Name of sample.	Remarks.
6	Selection II selected	Compared with No. 1, there seems to be not much difference except that No. 1 is more regular in fibre. Value Rs. 315.
7	Surti Broach	It cannot stand comparison to any of the above 6 samples, being shorter in staple and weak in fibre. Value Rs. 300.
	Sisodra Plot.	
1	Selection I selected	Of the three samples, 1, 2 and 3, No. 1 is the best, No. 2 comes second and No. 3 comes last. Value them respectively at Rs. 320, Rs. 315 and Rs. 310.
2	1027 ALF II General	
3	Navasari Local	
	Nadiad Farm.	
1	Lalio	This cotton shows deterioration on Nadiad Farm. Value Rs. 260.
2	Cambodia	This also has deteriorated considerably. Value Rs. 275.
3	Bhuri	This also shows deterioration and is very irregular. Value Rs. 255.
	Dhulia Farm.	
1	Surat-like	It shows a great deal of improvement, the cotton being almost equal to Surat in length and strength of fibre, though not in feel and silkiness. Value Rs. 305.
2	Broach-like	This shows no improvement. It is very irregular. Value Rs. 275.
3	N. R. Cotton	This cotton has more the characteristic of Assam cotton and woolly in feel. The staple is short. Value Rs. 220.

Basis of prices on 27th June 1914 :—

	Rs.
Broach	290
Madras Cambodia	330
Surat	315
Fine Bengal	215
Navasari	335
F. Dhollera	270

Kathiawar.—The following note was drawn up by Mr. Mankad, Assistant to Cotton Specialist, for the information of the Morvi State, which called upon us for special advice :—

" The District resembles South America in shape; the average rainfall is 18 to 22 inches, very irregular in distribution which tells considerably upon the production of the cotton crop.

Soils.—There are three kinds of soils, *viz.*, (1) black cotton soil, (2) besar and (3) light. The last named is chiefly met with in the southernmost part of the State towards Tankara.

Rotation.—Cotton is rotated mostly with Jowari in cotton soils, but in lighter kinds of soils Bajri forms the principal rotation.

The average area devoted to the culture of cotton in the State varies from 1,25,000 to 1,40,000 acres per annum. Broadly speaking, on account of enhanced prices of cotton, of late, two-thirds of the total cropped area is annually put out under it, as it pays better to the grower. The average outturn may be computed at 100 lbs. clean cotton per acre. In recent years, however, it has become the general practice to grow cotton without any rotation whatsoever, on the same land, and it is held amongst the cultivators that there is no diminution in the outturn. Economically the practice has proved a sound one owing to the high price of cotton.

Varieties of cotton.—Practically speaking, there are only two varieties in the State, called (1) *Deshi* or *Wagad* (bolls of which are picked out bodily from the plant and the cotton extracted at home), and (2) *Kanvi*, acclimatized Broach, the seeds from Kahnum of the Broach District seem to have been brought in these parts some 25 years ago; in addition to these two, there is a third variety called *Mathio*, mixture of all the *neglectum* types that compose the cottons of Khandesh and Central Provinces, which occupies a very small area in the south of the district towards Tankara

and is grown in light soils only, to get the crop ready before frost occurs as this tract is more subject to it.

The actual area under each of these three varieties is not separately kept, but it is understood that *Deshi* or *Wagad* occupies the largest area. Of the two principal varieties, *Wagad* is raised purely as a dry crop, but *Kanvi*, wherever there are facilities for irrigation, is given two or three waterings; as an irrigated crop, it gives a larger return. *Kanvi* matures also three weeks earlier than *Wagad*, the picking of *Kanvi* cotton is easier than that of *Wagad*, as it bursts out from the capsules when the bolls ripen; in the case of *Wagad* cotton, however, the opening of the bolls is not perfect, so that the bolls are plucked off and cotton extracted at home, which entails extra expenditure.

Forty pounds of *Wagad* bolls give 28 lbs. of *kapas* after extraction. The charges for taking out cotton from the unopened bolls vary from one anna to three annas according to seasons. This work is mostly done by women.

There are three distinct cotton tracts in the State according to the quality of cotton produced.

(1) The eastern portion is known as the Nadipar, which is practically free from frost, the cotton produced in this tract is offered 4 annas more per maund than that produced in the Boidiar tract.

(2) The western portion is called the Boidiar tract (there are many *bor* trees, *Ziziphus jujuba*). This is partially subject to frost. The produce of this tract is considered inferior to that of Nadipar but better than that of the Tankara tract. In this tract *Wagad* cotton is pollarded. Cultivators believe that the yield and quality of the rattooned crops are maintained. This belief is incorrect. The rattoon crop was valued at Rs. 245 per candy against Rs. 255 of the fresh crop of *Wagad*, the rattoon crop is also bound to fall off in ginning percentage in addition to the quality of cotton. I am informed

that a large area is kept under the rattoon in this tract in order that the crop may be picked out before the frost occurs.

(3) The southern portion is known as the Tankara tract which generally suffers from the effects of frost. *Mathio* is, therefore, grown in lighter kinds of soils to get an early crop. As *Mathio* produces a very small crop, the produce is usually mixed up with two principal varieties already mentioned. The quality of cotton of this tract is considered inferior to that produced in the eastern and western portions.

With regard to the quality of cotton, I feel that both *Wagad* and *Kanvi* are equally good. The crops vary slightly according to seasons only.

Kanvi.—The staple is slightly longer, fibres weak, cotton dull in colour and thin.

Wagad.—The staple is slightly shorter, but strong and white in colour, in addition, the cotton is *bulky.*

Bulk for bulk *Wagad* cotton fetches on an average Rs. 10 more per candy than *Kanvi.*

Samples of both these varieties were obtained from each of the three tracts and were submitted to Messrs. Tata, Sons & Co. for opinion. The following are the valuations of each of these samples.

Basis of valuation on 6th May 1914 :—

	Rs.
Fine Broach	265 per candy of 784 lbs.
Morvi	250 ,, ,,
Nadipar tract.	
Wagad from Jetpur	240
Kanvi	235
Boidiar tract.	
Wagad	255
Kanvi	250
Aroora (rattoon)	245

Tankara tract.

	Rs.
Wagad	250
Kanvi	240

From the valuation report it will be seen that the quality of cotton of the Boidiar tract is superior, then comes the Tankara tract and lastly the Nadipar, which ought to come first. This is puzzling, but it may be capable of explanation. My own observations in these three tracts lead me to believe that in the Nadipar tract, cotton matures a little earlier than in the other two tracts and being adjacent to the Dhrangadhra State, should produce cotton of better quality. The same two varieties are being grown in the Dhrangadhra State and fetch Rs. 10 more per candy than the Morvi cottons in the Bombay market.

Selection of seed.—It is gratifying to note that the *kunbis* who form a majority of the agricultural class are exceptionally keen on selecting well-opened bolls and hand-gin the same for seed requirement. Seed for sowing purposes is never brought in either from the ginneries or from Banias' shops by the *kunbi* cultivators.

Seed for sowing is also carefully stored in earthen *chattis.*

Hand-gin.—This differs from that used in other parts of India (excluding Kathiawar). It is an ordinary gin to which a fly-wheel is attached, the price of such a gin depends on the quality of the fly-wheel, but it may be taken at Rs. 10 to Rs. 15. The work done by this hand-gin with the *herbaceum* types of cotton is 160 lbs. of *kapas* per day, working at the rate of 12 hours a day requiring two men and one woman.

In addition to ginning cotton for seed requirements, the *kunbi* cultivators take out sufficient seed for cattle for the year by means of such gins; a portion of the lint obtained is spun by hand for making clothes, ropes, etc., to meet domestic and agricultural requirements and the surplus is sold. The hand-ginned cotton fetches Rs. 10

less than the machine-ginned per candy, as the former contains comparatively a larger percentage of broken leaf, dirt, etc.

With regard to general cultivation, it should be mentioned that the *kunbi* cultivators are first class people in handling the land. The cotton fields were found scrupulously clean throughout and the agricultural operations perfect. The standard of cultivation could, however, be raised by deep-ploughing, etc.

As the rainfall is very precarious, it is suggested that a bullock-hoe of the Surat type (curved blade) for interculturing might prove more beneficial than the local hoe in the conservation of soil moisture. I have personally explained its advantages to the Revenue Commissioner and the Patel of Mandan. A blade of the Surat hoe has already been sent from Surat.

Varieties actually under trial.—In the Kesawala garden, trials were made in sample plots with five varieties including two perennial cottons, *viz.*:—

(1) *Kumpta* (seed obtained from Miraj).

(2) *Dharwar American* and *Cambodia* (Upland types).

(3) Seed received from Rangoon (*Neglectum* types).

(4) And with varieties of perennial cottons, *viz.*:—

Spence and *Kidney* or chain-seeded.

All these had received waterings.

(1) *Kumpta.*—The growth was satisfactory, the crop had not ripened but a few bolls that had opened were examined; cotton was thin on seed, as is usually the case with this variety, though the quality of cotton was almost equal to *Kumpta* of the Southern Mahratta Country. The local cotton (*Wagad* or *Deshi*) is superior in all respects to *Kumpta*, as the percentage of cotton to seed is greater than the one under trial, and the cotton is also bulky.

(2) *Dharwar American* and *Cambodia*.—The former had practically failed, on account of the attack of leaf blight, the latter grew satisfactorily, branching in all directions. On examination the fibre was found weak and the staple comparatively short, though it showed high percentage of cotton to seed. This quality may fetch Rs. 20 to Rs. 25 more per candy over the local cotton.

These varieties were planted out too far apart (6 feet on either side). The American annual forms are grown in the same way as the local cottons, *i.e.*, lines 2 feet apart and distance from plant to plant 1 to 1½ foot in the row.

(3) *Seed from Rangoon*.—The resulting plants were of the *neglectum* type, the ripening period had considerably prolonged, probably due to irrigation. In parts where the *neglectum* types are grown, the crop requires five to six months only to mature. The quality of cotton is in no way superior to the local cotton; it should, therefore, be abandoned. This is something like *Mathio* cotton.

(4) and (5) *Spence and Kidney cottons* (*perennial varieties*).—These had made very unsatisfactory progress. Results of a few years' experiments proved plainly that all the varieties of tree cottons possessed so many inherent defects that their profitable cultivation was impossible *on a field scale.*

Mr. Spence's attempts at the cultivation of *Spence* variety on a large scale at Deesa and Jamnagar, Mr. Tytler's at Belgaum with *Rough Peruvian* and Messrs. Shaw, Wallace & Co.'s in Bengal with *Caravonica* and almost all tree cotton varieties hopelessly failed and no one reports even moderate success with them.

The chief drawbacks in their cultivation are :—

(1) Their very structure is that of woods and sheltered places.

(2) Their brittle nature forbids their being grown in open fields exposed to winds.

(3) They are more subject than the annuals to insect pests and these are carried from year to year and the land becomes weed-infected.

(4) And finally, the steadily decreasing annual outturn is the strongest argument against their cultivation.

In conclusion, it can safely be said that the tree cotton which will succeed in India as a *field crop* has still to be discovered and it is extremely risky to attempt the hopeless task of tree cotton cultivation on a commercial scale.

In the new garden, I was shown about half a dozen grafts that had been made between the *Arboreum* and *Deshi* cotton according to the new discovery by a German named Schætin. It has been suggested to collect all the cotton when the bolls ripen and to put out a larger area next season to test the results. In our opinion, it is highly probable that the cotton plant with its brittle wood and tough fibrous inner bark does not allow of any process of grafting, which will produce frost-resistant types possessing desirable quality of cotton.

I was taken over the proposed area of 2,000 acres in 3 blocks in the Tankara tract, which is to be left at the disposal of an American expert, whose services have been lately acquired, to test the suitability of various crops. Most of the land is under cultivation, flat, with facilities for irrigation, in fact, beautiful to work with and it is hoped that the authorities will spare no pains to tackle various points connected with the improvement of cotton.

I had also an interview with His Highness the Thakore Saheb of Morvi, who takes keen interest in the improvement of the cotton crop, and we discussed the cotton question at full length. He desired to try *Broach* seed, which has been supplied. As the rainfall is scanty, I am afraid that the long duration of growth required by *Broach* cotton might tell upon the opening of the bolls.

In conclusion, I think that the two local varieties *Wagad* and *Kanvi* are in every respect suitable to these parts and the products meet the demand quite satisfactorily. As the conditions of soil and climate do not seem to favour any other variety, either Indian or foreign, I would suggest that attention should be directed to increase the outturn by better methods of cultivation and improve the ginning percentage of each of the two local varieties by selection. An attempt should also be made to distribute seed of *Wagad* and *Kanvi* from the Dhrangadhra side, which produces better quality of cotton. At the same time arrangements should be made with the expert to test the suitability of Cambodia *under irrigation* and of imported Broach seed."

In this connection, the following letter was received from the Manager and Executive Engineer, Morvi State :—

" Mr. D. P. Mankad came here on the 3rd instant and stayed up to the 10th. He visited different Mahals of the State and made his journey on our tramway of a length of about 60 miles, where the principal crop is cotton. He was also shown the different varieties of cotton under trial in the State gardens. Thus every facility was given to him to visit the different parts of the State, so that he can send in his full report. I shall therefore feel very much obliged if you will kindly send me a copy of his report.

We are very much obliged to you for the help you have given us by sending Mr. Mankad, who was very busy here during his stay with his work and for this he also deserves our thanks in no less degree."

The Director of Agriculture, Baroda, submitted for valuation two samples of cotton grown in Kathiawar at Kodinar.

The first, of *New Orleans* type, was selected out of the prevailing mixture in the fields and grown separately to ascertain its value. The plot was flooded three times by heavy rain during the season. In spite of this a yield of 208 lbs. of seed cotton per acre was obtained, the ginning percent-

age being 30·3. The clean cotton was valued by Messrs. Tata, Sons & Co. at Rs. 315, compared with Sind American of the same date at Rs. 310.

The value of the second sample, which was a selected local *Mathio*, was Rs. 190, equal to fine *Mathio* of the day. No figures of outturn were supplied with this.

It has been suggested to the Director to repeat these trials during the present season.

Southern Mahratta Country.—The following notes were sent to the Director of Agriculture, Bombay, after an inspection of the cottons in the Southern Mahratta Country :—

" Dharwar.—There are now series of 10 generations of *Broach* cotton on this farm. The percentage has dropped to 29, which is, however, about 4 to 5 per cent. higher than the maximum of *Kumpta*, so that, judged on this point alone, it still leads.

Some members of the local Agricultural Association have offered to grow annually 300 acres of *Broach* from imported seed and to guarantee the distribution of seed only from cotton of the first class from this area, the standard to be fixed when lots are ginned to ascertain the percentage. This seems to be the most practicable plan to ensure the continuous supply of selected *Broach* seed in the District.

The longer growing season of *Broach* would always be a strong factor against the possibility of its ever supplanting *Kumpta* in any great degree. By steady selection the ginning percentage in *Kumpta* has been raised to 29, an advance of 4. It is quite possible that, by steadily aiming for percentage, a still further increase could be arrived at.

The cultivation of *Cambodia* has been abandoned at Dharwar. The crosses between *Soft Peruvian* and *Cambodia* are not promising after all; they seemed to have retained the perennial character and may fruit if held over for another season. As perennial cottons have

been proved unsuitable for conditions in India, there seems no good ground to justify the maintenance of these crosses.

One hundred pounds of selected *Kumpta* seed have been given out, but no results are yet available. It has been proved that the use of a fence of *Sherri* as a wind break is not practicable, as it exercises a distinctly bad influence on contiguous crops.

As far as I could gather, there is no dissatisfaction expressed regarding the quality of the imported Navasari seed this year.

Gadag.—This farm is now restricted to trials with American types of cotton. As at Dharwar, the cross between *Cambodia* and *Soft Peruvian* is not at all promising.

The whole of the *Cambodia* is now treated as being one variety, and the trials are directed with a view of keeping up the standard of staple and percentage.

The two forms of *Dharwar American*, which were isolated upon my advice last year, have been grown with a high percentage of purity. There is still a doubt as to whether the Upland or New Orleans type is superior. I am informed that some of the villages producing superior Dharwar American cotton are said to grow the New Orleans type exclusively. I have suggested that a fresh survey of these types in the district should be undertaken."

The following valuations were kindly supplied by Messrs. Tata, Sons & Co. :—

Valuations.

Basis of prices on 11th June 1914 :—

	Rs.
(1) Navasari	335
(2) Surat	320
(3) Madras Cambodia	310
(4) Kumpta	290
(5) Fine Broach	285
(6) Sawginned	265

Serial No.	Registered No.	Name.	Valuation.
		Dharwar Farm.	
1	1027A	Kumpta X Ghogari (Surat Cross)	We place them in the following orders as regards length of staple and general quality: first No. 2, second No. 3, third No. 4, and then No. 1. Of Nos. 5 and 6, No. 5 is better than No. 6. We value:—No. 1 Rs. 305, No. 2 Rs. 325, No. 3 Rs. 320, No. 4 Rs. 305, No. 5 Rs. 300, No. 6 Rs. 295.
2	1364	Do. Dharwar Cross old	
3	2003	Do. Dharwar Cross new	
4	1339	Kumpta Cross	
5	...	Kumpta selected for quality	
6	...	Do. for quantity	
7	...	Broach, 1st generation (new seed)	Of these, No. 8 is the best. No. 7 comes next and rest are almost all more or less equal, though we find that Nos. 13, 14 and 15 are a little better than Nos. 9, 10, 11 and 12. We value:—No. 7 Rs. 310, No. 8 Rs. 315, No. 9 Rs. 300, No. 10 Rs. 300, No. 11 Rs. 300, No. 12 Rs 300, No. 13 Rs. 305, No. 14 Rs. 305, No. 15 Rs. 305. Compared with No. 28, No. 7 is superior to it in length of staple, and is rather thin.
8	...	,, 2nd ,,	
9	...	,, 3rd ,,	
10	...	,, 4th ,,	
11	...	,, 5th ,,	
12	...	,, 6th ,,	
13	...	,, 7th ,,	
14	...	,, 8th ,,	
15	...	,, 9th ,,	
		(Old seed introduced in 1901.)	
16	2016	Kumpta X Comilla	The crossing has materially improved in the length and strength of staple over Assam. There seems to be no deterioration. If anything, it has improved. Value Rs. 285.
17	1027A	Kumpta X Ghogari	In crossing, it has obtained white colour of Ghogari and in staple it is ordinary Kumpta. Value Rs. 290.
18	1339	Kumpta Cross	It seems to have improved. Value Rs. 300.
19 & 21	...	Kumpta ordinary ,, ,, from plot 608	Compared with Nos. 1 to 6, there can be no comparison with them, since both are very inferior as regards length and strength of staple. Of the two, No. 19 is superior to No. 21 which is even weaker than Kumpta in the local market. Value No. 19 at Rs. 280, and No. 21 at Rs. 260.

Serial No.	Registered No.	Name.	Valuation.
20	102E	Cambodia	The cotton is very weak in fibre and irregular in length. Value Rs. 280.
22	...	Cultivator's Kumpta . . .	It is no way superior to ordinary Kumpta, equal to local cotton. Value Rs. 290.
		Gadag Farm.	
23	...	Dharwar American (Green-seeded)	It is better than ordinary Sawginned coming in the local market. Value Rs. 280.
24	120E	Cambodia	This cotton seems to be little better than No. 20 of the Dharwar Farm, but still it is weak in fibre. Value Rs. 300.
25	1345	Christopher X Christopher .	It is longer in staple than No. 24, but equally weak. Value Rs. 310.
26	1356	Christopher X Culpepper . .	This is a very long stapled strong fibred cotton. Every way a desirable stuff. Value Rs. 360. This deserves to be widely cultivated.
27	...	Dharwar American (Gadag-Market sample).	This seems to be a mixture of Sawginned and Kumpta kappas. Hence there seems to be some strength in the fibre. Otherwise the cotton is of very inferior quality. Value Rs. 260.
		Gokak Farm.	
28	...	Broach New seed . . .	It is slightly inferior in length of staple than Navasari. Value Rs. 320.
29	1339	Kumpta Cross	It has improved in every way. Value Rs. 295.
30	...	Kumpta Ordinary . . .	It has lost in length of staple. Value Rs. 285.
31	102E	Cambodia	It has entirely deteriorated on the Gokak Farm. Value Rs. 275.
32	...	Cultivator's Kumpta (Arbhavi) .	It is better in length than farm Kumpta No. 30. Value Rs. 290.

Of four crossed cottons, *Kumpta X Ghogari* (Dharwar Cross old) was valued at Rs. 325; *Kumpta X Ghogari* (Dharwar Cross new) valued at Rs. 320; *Kumpta* Cross valued at Rs. 305; *Kumpta X Ghogari* (Surat Cross) valued at Rs. 305.

Kumpta selected for quality was valued at Rs. 300 and the same selected for quantity at Rs. 295. The samples of *Kumpta* ordinary cotton were valued at Rs. 280 and Rs. 260, thus testifying to the far higher value of the improved varieties given above. A sample of cultivator's cotton from Dharwar was valued at Rs. 290, equal to local cotton. Another *Kumpta* Cross was valued at Rs. 295. A sample of cultivator's *Kumpta* from Arbhavi was valued at Rs. 290. A sample of *Cambodia* from Dharwar Farm, where the conditions are unsuitable for it, was valued at Rs. 280 only, on account of its weak and irregular fibres; even a sample from the Gadag farm, where the conditions are far more favourable, was valued at Rs. 300 only. Green-seeded Dharwar American from the Gadag farm was valued at Rs. 280. A market sample from Gadag seemed to be a mixture of *Dharwar American* and *Kumpta*. It was valued at Rs. 260. Of the Upland Crosses, that of Christopher X Culpepper seems to hold the first position in value. Messrs. Tata remarked that this is a very long stapled, strong fibred cotton and, in every way, desirable stuff, which deserves to be widely cultivated. They valued it at Rs. 360.

Of the 9 generations of Broach cotton at the Dharwar Farm, Messrs. Tata valued 2 at the best, 1 as the second, and the rest more or less equal, though they found 7, 8, 9 a little better than 3, 4, 5, 6. Last year, it appeared that the deterioration was continuous, but, from this year's figures, it would appear that after thorough acclimatization perhaps an improvement may set in.

The auction sale of Broach Cotton.—The auction sale of *Broach* cotton was held at Dharwar on the 12th April 1914. In all 80,000 lbs. seed was distributed during the

year 1913-14 (30,000 lbs. seed imported from Navasari and 50,000 lbs. locally grown Broach cotton seed).

All the seed was not sown for want of timely rains, the approximate area sown would be between 4,000 and 5,000 acres.

Sowing commenced from the end of June to middle of July.

Season on the whole was not favourable either to Broach or to local cotton *Kumpta*.

There were no late rains and consequently cotton plants suffered.

In all 3,500 *dhokras* of *kapas* were received (4 *dhokras* are equal to 1 *Naga*, that is, equal to 1,344 lbs.) at the auction Depôt. I am informed by the Agent of Messrs. Tata, Sons & Co. that more than 300 *Nagas* were sold away by the cultivators before the auction sale for immediate requirement of money.

Broach cotton at the Depôt was graded in six classes according to ginning percentages.

The following prices were realised per *Naga* of 1,344 lbs. :—

Class.	Ginning percentage.	Price.
		Rs.
Special class—	34 and above	190
I . . .	33·5	185
II	32·5	176
III	31·5	175
IV	30·5	171
V	29·5	155
Kapmta Cross . . .	27·5	139

The rate of the local cotton *Kumpta* on the day was Rs. 129 per *Naga*.

The low ginning percentage may be due to (*a*) the deterioration of the local cotton seed, (*b*) poor ginning percentage of the last pickings.

The representatives of the Bombay mill-owners and the local merchants who attended the sale were thoroughly pleased with the quality of cotton and believed that the stuff was similar to Navasari cotton except that the staple was rather rough and added that there will be no difficulty in realising good prices for this class of cotton up to 10,000 *Nagas*, and wished that the cultivation of this cotton should be extended.

There were no complaints regarding the quality of seed, but it is absolutely necessary to renew every year a large quantity of Navasari seed to keep up the standard of staple and ginning percentage.*

It is interesting to know that a man who had put out only 6 acres under *Broach* cotton, realised Rs. 574 at Rs. 95 per acre.

Cambodia Cotton.—The cultivation of this cotton has been tried in so many diverse localities that it is as well to collect all our scattered references under one head.

Guzerat.—Mr. Mankad has supplied the following note on Cambodia prospects in North Guzerat as the result of his inspection in November last :—

" Believing that the cultivation of *Cambodia* must have spread at Bawla, I went there on the 9th November, when I was informed that the cultivation was not undertaken during the present year.

The glowing report on this cotton is said to have had some effect in a village called Vasna in the Dholka Taluka and it is reported that a few acres have been put under this cotton. It is a fact that *Cambodia* seed in these parts was sold at an enhanced rate, 5 to 6 rupees per maund of 40 lbs.

* The ginning percentage this year, on the whole, seems to be high throughout.

The details of the three methods of cultivation of both, *Bhuri* and *Cambodia*, in the Goradu soil on the Nadiad Farm are as follows :—

(1) Start given by two waterings from May.

(2) Rain-fed.

(3) Two waterings to be given after the cessation of rains.

The new exotics were found attacked by wilt and aphides. White-ants had also destroyed a good many plants. Judging from the growth of the plants, the local cotton, *Lalio*, appeared more promising. *Bhuri* seems to be hardier and earlier in ripening (3 weeks) than *Cambodia*, but the low outturn combined with a low ginning percentage and a weak fibre are the greatest objections to it.

Cambodia tried at Shahpur near Petlad and at Cambay in the Kaira District also suffered from the attacks of leaf-rollers and aphides. The experimenters now report that the outturn is disappointing.

I am inclined to think that the following points do not seem to appeal in favour of *Cambodia* :—

(1) During the very first year of its trial in 1912-13 it gave a decidedly low ginning percentage on the Farm, and it seems doubtful whether it will keep up both in quality and ginning percentage; these two factors are of vital importance in the successful cultivation of cotton.

(2) Being a delicate variety, it is more susceptible to insect pests than the local cottons.

(3) Unless cultivation extends fairly on a large scale there seem small prospects of establishing a market for the disposal of this kind of cotton. It is also a question how far the product will be kept thoroughly pure.

(4) It seems difficult in practice to start the crop under one or two waterings in May to get good returns.

> Irrigating the crop after the cessation of rains is likely to prolong the period of maturity."

In the Cambay State, 4 acres were put out, yielding at the rate of 140 lbs. seed cotton per acre. The sample of the clean cotton was submitted to Messrs. Tata, Sons & Co., who remarked that " the cotton seemed to be carelessly picked and ginned. It has retained the length of fibre and silkiness. We value it on Dhollera Basis Rs. 10 below Dhollera at Rs. 250. We may mention that if it had been carefully picked and ginned, it would have fetched Rs. 265 per candy."

In the Kaira District, at Shahpur also *Cambodia* was given a trial. The crop suffered badly from insects and no outturn figures were supplied, but the sample of the product was valued at Rs. 270, *Cambodia* on the day being at Rs. 290.

Dhrangadhra (Kathiawar).—Half an acre of *Cambodia* from seed supplied by us yielded 12 maunds and 30 seers (510 lbs. of seed cotton), as an irrigated crop, whereas *Kanvi* local cotton yields 10 maunds (equal to 400 lbs.) for half an acre in open fields; a mill-owner estimates that *Cambodia* would fetch 16 per cent. more than the price of the local cotton. A sample of this *Cambodia* cotton was reported on as follows by Messrs. Tata, Sons & Co. :—

" It is out and out superior and is the best *Cambodia* of the samples examined to-day. We value it at Rs. 320, equal to Navasari and Rs. 5 over the basis of Madras Cambodia."

Further trials are to be made this season in dry land.

The auction sale of Cambodia cotton.—The auction sale of *Cambodia* cotton took place on the 19th April at Gadag.

The area under this cotton was much limited during the year owing to its failure during the year 1912-13.

Purified Madras seed was distributed in the Gadag and Ron Talukas of the Dharwar District.

About 500 to 600 acres were grown under *Cambodia*. Sowing took place in the middle of September. The season was not favourable to any class of cotton and I am inclined to think from personal observations that *Cambodia* comes out well in a *bad season*.

In all 587 *Dhokras* (4 *Dhokras* make one *Naga* of 1,344 lbs.) were received at the auction Depôt.

The cotton was graded in 6 classes according to ginning percentages and realised the following prices per *Naga* of *kappas* (1,344 lbs.) :—

Class.	Ginning percentage.	Price.
		Rs.
Special Class purified	37 and above.	196
I	36·5	187
II	35·5	180
III	34·5	177
IV	33·5	172
V	32·5	166

Except the special class other classes may have an admixture of *Uppam* and *Karunganni* plants to a small extent and this may account for slightly low ginning percentage.

The local cotton *Dharwar American* on the day stood at Rs. 126 per *Naga* of 1,344 lbs.

N.B.—The cotton was perfectly clean but harsh to touch, staple also shorter than the standard of Cambodia.

The cotton of the special class was thoroughly purified by the Department and it is intended to distribute seed of this class only, together with that received from the Gadag Farm.

On the whole, the auction sale was a great success and *Cambodia* fetched very satisfactory prices. It is possible that the cultivation will considerably extend during the ensuing year.

Messrs. Tata, Sons & Co. have kindly furnished the actual valuations of all the five classes :—

	Rs.	
Special Class	275	Being ginned not in ordinary gins but in sawgins, the staple seems to have been cut and cotton presents a happy appearance. We value them on the basis of the value of sawginned at Rs. 270.
I ,,	280	
II ,,	290	
III ,,	270	
IV ,,	285	

Basis on 17th July 1914 :—

	Rs.
Madras Cambodia	315
Sawginned	270
Navasari	320
Kumpta	275

From the valuations, it will be seen that the trade appreciate the ginning percentage and not the quality so much.

As in former years, I have to thank Messrs. Tata, Sons & Co. for the care and trouble they have taken in furnishing valuations of the numerous samples of cotton submitted to them.

III.—Programme of work for the year 1914-15.

(1) To visit and advise on points regarding cotton and its cultivation whenever requested to do so by Provincial Departments of Agriculture.

(2) The study of the behaviour of *Bourbon*, *Bhuri*, *Cambodia* and other such cottons in non-cotton-producing tracts, as detailed in the last year's programme, will be continued.

(3) An enquiry on the manurial requirements of cotton will be continued.

(4) Researches on the botany of cotton will be continued.

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REPORT

OF THE

Agricultural Research Institute and College, Pusa

(Including the Report of the Imperial Cotton Specialist)

1914-15

CALCUTTA
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Report of the Agricultural Research Institute and College, Pusa,

(Including the Report of the Imperial Cotton Specialist)

1914-15.

REPORT OF THE DIRECTOR.

(Bernard Coventry, C.I.E.)

I. Charge and Staff.

Charge. I held charge of the office of Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, and Mr. Wynne Sayer, B.A., of the office of Assistant to the Agricultural Adviser to the Government of India throughout the year.

Mr. A. C. Dobbs, B.A., who was the permanent Assistant to the Agricultural Adviser was transferred to Ranchi as Deputy Director of Agriculture under the Government of Bihar and Orissa on the 26th April 1915 and Mr. Sayer has been appointed to the post.

Staff. The Chemical Section was in charge of Mr. J. W. Leather, V.D., F.I.C., during the year.

Mr. Jatindra Nath Sen, M.A., Supernumerary Agricultural Chemist, has been posted at the Agricultural College at Sabour since September 1914 for research work.

Mr. A. Howard, C.I.E., M.A., held the office of the Imperial Economic Botanist during the whole year. Gabrielle L. C. Howard, M.A., has been appointed as Second Imperial Economic Botanist, from 10th February 1915. As in previous years Mr. and Mrs. Howard proceeded to Quetta in May 1915 and will stay there for five months for work in connection with the development of the fruit industry in Baluchistan.

Dr. E. J. Butler, M.B., the Imperial Mycologist, was on leave during the year. Mr. F. J. F. Shaw, B.Sc., Supernumerary Mycologist, who has been appointed to officiate as Imperial Mycologist was in charge of the Mycological Section.

Mr. T. Bainbrigge Fletcher, F.E.S., F.Z.S., held charge of the Entomological Section.

Mr. A. J. Grove, M.Sc., Supernumerary Entomologist, was on deputation to the Punjab to carry out work on grain pests and cotton boll-worm till 27th April 1915 when his services were terminated on expiry of his probationary period.

Mr. F. M. Howlett, B.A., F.E.S., remained in charge of the Pathological Entomological Section during the year except for the period from 30th August to 22nd September 1914, when he was on privilege leave.

The Bacteriological Section was in charge of Mr. C. M. Hutchinson, B.A., throughout the year. Mr. J. H. Walton, B.A., B.Sc., Supernumerary Agricultural Bacteriologist, has been appointed to the Indian Army Reserve of Officers. He left Pusa on the 4th June 1915 to join his duties in the Military Department.

Mr. A. C. Dobbs, B.A., remained in charge of the Agricultural Section till 25th April 1915 when Mr. S. Milligan, M.A., B.Sc., on return from leave resumed charge of the duties of the Imperial Agriculturist. The two posts of Supernumerary Agriculturists are now vacant, as Mr. Sayer has been appointed as Assistant to the Agricultural Adviser to the Government of India from 26th April 1915, and the services of Mr. G. D. Mehta, L.Ag., B.A., Supernumerary Agriculturist, who was posted to Madras for training, were terminated on 31st March 1915, on the expiry of his probationary period.

II. Work of the Institute.

Scientific Work. The scientific work of the Institute during the period is indicated in the reports of the various sections.

Training. The post-graduate course students continued to receive training and short courses were also given in Sericulture and Lac culture.

The probationary research assistant under the Agricultural Chemist to the Punjab Government referred to in the last year's report completed his training in Agricultural Bacteriology during the year under report and the student deputed by the Department of Agriculture, Central Provinces, is under training in the same section. An assistant deputed by the Indian Tea Association is also under training in Agricultural Bacteriology.

In the Botanical Section a graduate of the Sabour Agricultural College deputed by the Bengal Department of Agriculture and a graduate of the Poona Agricultural College deputed by the Bombay Department of Agriculture completed their training in Botany during the year under report. The latter after finishing his course at this Institute has proceeded to England with a scholarship from the University of Bombay for further training in plant-breeding work.

A Fieldman deputed by the Principal, Agricultural College, Sabour, is undergoing training in Mycology in the Mycological Section.

In the Entomological Section an assistant deputed by the Punjab Government and a private student who is a graduate of the Lyallpur Agricultural College are under training in general Entomology.

Besides the regular students referred to above the following visitors also worked in the laboratories :—

Mr. B. L. Gupta, Professor of Biology, Reid Christian College, Lucknow, referred to in the last year's report, completed his course in Mycology and left on 8th July 1914. Mr. S. L. Ajrekar, B.A., Assistant Professor of Mycology, Poona Agricultural College, worked in the Mycological Laboratory from 28th October to 5th November 1914.

Mr. Awati worked in the laboratory of the Pathological Entomologist for some time at the taxonomics of *Muscidæ.*

III. Publications.

The Agricultural Journal of India, Scientific Memoirs and Bulletins continued to be issued during the year. The Department published during the year 13 Memoirs and 14 Bulletins. Of these a fair number was contributed by the Provincial Departments. The memoirs continued to maintain their standard of excellence and were much in request from scientific institutions abroad. The bulletins containing matters more of practical than scientific interest continued to be in good demand particularly in India. They covered a large range of subjects such as sugarcane crushing, sugar machinery and manufacture, bee-keeping, improvement of indigo cultivation and sericulture. Among these bulletins four were contributed by the Provincial Departments and one containing notes on sugar machinery and manufacture in Northern India is a report by Mr. Peter Abel, an authority on the manufacture of sugar, who toured in this country with a view to advise the Government of India in connection with sugar matters generally. The grant for publications amounting to Rs. 29,000 has been made permanent. It has been decided to publish a revised edition of the Manual of More Deadly Forms of Cattle Disease in India. This useful manual was last revised in 1903, and opportunity has been taken to bring it up to date and to practically rewrite it. This will considerably add to its utility.

As in the last two years, strictest economy was exercised with the result that it was possible to keep down expenditure within the sanctioned grant. But as the superior staff of the Department capable of making original investigations is continually increasing, the volume of matter offered for publication will tend to increase when the present grant will be found inadequate.

IV. General Administration.

Buildings and Works. During the year under report the construction of two additional bungalows for European officers and the extension of the Pusa Library were completed. Additional quarters for the subordinate staff of the Institute are under construction. The schemes for the installation of electric lights and fans in the European bungalows and the Rest House at Pusa and for the addition of a female ward to the Pusa hospital as well as the proposal for a new ice machine at Pusa have been sanctioned.

Library. The third edition of the catalogue of the Pusa Library will shortly be out. During the year under report over 500 volumes were added by purchase besides many foreign bulletins, memoirs, reports, etc., which are received in exchange from different parts of the world.

Pusa Schools. The Middle English School was raised to the status of a High School on 2nd January 1915, and one of the long felt wants of the residents was thus satisfied. The number of pupils attending the school at the close of the year was 185. It has a staff of one Head Master and 14 Assistant Masters and promises success. A Lower Primary Girls' School was also started on 20th February 1915.

General Health of the Station. The general health of the station during the year under report continued to be good. Medical relief was afforded to 10,217 persons of whom 9,969 were treated in the out-patients' department and 248 admitted as indoor-patients. Ninety-one cases among the European officers and their families were attended to.

The daily average number of patients treated was 69·19 out-door and 12·14 in-door.

Ten deaths occurred in hospital, some of these cases were brought to the hospital in rather advanced stages of disease.

The epidemic of cholera, which broke out in the villages in the immediate vicinity of Pusa during the months of May and June, threatened to be a source of great danger. Immediate and successful measures were taken to prevent its entering the Estate, the chief of which was keeping of the water supply pure by disinfecting and cleaning of the wells.

One hundred and ninety-eight surgical operations were performed of which 27 cases were major and 171 minor.

Fourteen primary and four re-vaccinations were performed during the year.

V. Accounts.

The total expenditure during the financial year 1914-15 was Rs. 4,79,825 as under :—

	Rs.
Office of the Agricultural Adviser to the Government of India and Director of the Institute	2,03,046
Chemical Section	41,807
Mycological Section	25,015
Entomological Section	43,142
Pathological Entomological Section	25,662
Botanical Section	38,220
Bacteriological Section	31,592
Agricultural Section	71,341
Total	4,79,825

Out of the grant of Rs. 1,10,000 for the development of the Indian Sugar Industry referred to in previous year's report, a sum of Rs. 35,000 was provided in the budget for 1914-15 for meeting the expenditure in connection with the engagement of Mr. W. Hulme as Sugar Engineer in the United Provinces.

A sum of Rs. 15,000 was paid as grant-in-aid to the Indian Tea Association.

The principal items of expenditure under the annual grant of Rs. 10,000 placed at the disposal of the Agricul-

tural Adviser to the Government of India for special Agricultural Experiments were as follows :—

	Rs.
Purchase of two Ayrshire bulls for the Pusa Farm and the Agricultural Department, Central Provinces	1,920
Contribution to the Bacteriological Section .	1,030
Distribution of Pusa wheat seed No. 12 in the United Provinces	4,000
Experimental cotton cultivation conducted by the Imperial Cotton Specialist . . .	1,500
Purchase of silk yarn for sericulture experiments at Pusa	240

The gross receipts during the year from the sale of farm produce, milk, publications of this Department and other articles amounted to Rs. 16,843 as against Rs. 22,157 of the previous year.

VI. Visitors.

During the year under report His Highness the Maharaja Bahadur of Darbhanga, the Hon'ble Sir Robert Carlyle, K.C.S.I., C.I.E., I.C.S., Member-in-Charge of Revenue and Agriculture, Government of India, the Hon'ble Mr. Lallubhai Samaldas, C.I.E., Member of the Legislative Council of the Government of Bombay and Mr. A. E. English, C.I.E., Registrar of Co-operative Societies, Burma, and many others visited the Institute.

REPORT OF THE IMPERIAL AGRICULTURIST.

(S. Milligan, M.A., B.Sc.)

I. Administration and Tours.

Mr. Dobbs continued in charge of the Agricultural Section until my return from combined leave on April 25th, 1915.

The number of the Supernumerary Staff has been reduced to *nil* owing to the termination of Mr. Mehta's agreement and the appointment of Mr. Sayer to the post of Assistant to the Agricultural Adviser.

Mr. McLean, Deputy Director of Agriculture, Bengal, and Mr. D. R. Sethi, Deputy Director of Agriculture, Bihar and Orissa, were posted to Pusa for preliminary training for periods of three and four months respectively.

Mr. Judah Hyam, Veterinary Overseer, continued in charge of the breeding herds. Mr. L. S. Joseph, Veterinary Assistant, acted for him in addition to his own duties for one month.

Mr. Md. Ikramuddin held the post of 1st Farm Overseer during the year. He was on privilege leave for three months from 2nd January to 31st March 1915.

Mr. Arjan Singh held the post of the 2nd Farm Overseer throughout the year and officiated for the 1st Farm Overseer for three months from 2nd January to 31st March 1915 in addition to his own duties.

Babu Brajaraj Mukerji, Fieldman, was promoted to the post of senior fieldman from 1st April 1915.

Mr. Imdad Hoossain Khan has been appointed as a Fieldman on Rs. 50—5—75 on probation for three months from 15th May 1915.

Mr. Dobbs visited Ranchi in October 1914 and the agricultural stations of Bengal, Bihar and Orissa, and the Central Provinces in December and January.

Mr. K. P. Roy from Bengal, attended the general course of instruction in Agriculture from 4th June to 16th September 1914.

II. Farm Cultivation.

Character of the season. The total rainfall of the season (June 1914 to May 1915) amounted to 54·88 inches. An abnormally heavy fall in August (28 inches) caused serious flooding in the lower lands and affected both the standing crops and the ensuing *rabi* crops.

Crop Experiments. The field experiments dealing with the maintenance of soil fertility under a double cropping system (*i.e.*, two crops per annum) by the use of manures, have been continued. The green manuring experiments in collaboration with the Imperial Agricultural Bacteriologist have been altered in accordance with the experience gained. A large expansion of "quantitative" experimental work will not be possible for a few years until the land recently laid out for this purpose has been properly tested.

Cultivation. The Fowler's double engine tackle purchased in 1913 has proved its suitability to special circumstances with careful supervision. As was pointed out by Mr. Dobbs in last year's report Pusa Farm is far from being ideal for the use of such machinery and much better economic results could undoubtedly be obtained under more favourable conditions. The tackle is, however, of particular value at Pusa, with its large area under crop, in lightening the work of the supervising staff, and allowing of more concentration on experimental work and necessary improvements. The writer considers it premature to express any definite opinion as to the economic value of such tackle until correct figures can be worked out for depreciation and repairs which cannot be done while the machinery is new.

Trials of a new type of motor plough were undertaken for the makers. Some modifications of the engine to suit

the Indian climate have proved necessary and are being introduced.

III. Live-Stock.

Cattle Breeding. As mentioned in last year's annual report two herds are now being maintained at Pusa one of selected Sanhiwal (Montgomery) cows and their descendants, the other of cross-bred Ayrshire-Sanhiwal cattle.

As the breeding operations have since 1912 been based entirely on the milk records of the females the initial steps have been completed towards the building up of "milk pedigree" but results will not be apparent until the calves of the present generation have grown up.

The cross-breeding operations with imported bulls must be considered as purely experimental, the primary object being to gain information regarding the transmission of characters, valuable or otherwise, of the exotic breed.

Sheep Breeding. The operations as described in last year's report, *viz.*, the crossing of local sheep with Merinos with a view to gaining information regarding the inheritance of wool characters, have been continued. There is nothing to report as the second generation of cross-breds has not yet been produced.

IV. General.

Drainage. A new protective drainage scheme has been completed. The Pusa Estate has now been provided with its own outlet to the river and a pumping station has been erected to deal with excess water in times of high river levels.

The main drains of the low-lying area have been enlarged. New roads have been made to improve the shape of the fields and a new field added to the experimental area. Experiments in puddling rice land with steam disc harrows are in progress and arrangements have been made to control the irrigation and drainage of the rice area.

V. Programme of work for 1915-16.

The following are the lines of work in progress :—

Major investigations.

1. The economics of cultivation by steam and motor engines.
2. The puddling of rice land by the double engine system of steam cultivation
3. The combination of irrigation and drainage in the growing of rice.
4. A study of inheritance of the more important characters of dairy cattle by crossing.
5. The building up of milk pedigree in cattle by selection.

Minor investigations.

6. The inheritance of wool characters in sheep.
7. Experimental tillage in the growing of maize and sugarcane.
8. Improvement of pastures.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(J. WALTER LEATHER, V.D., F.I.C.)

I ADMINISTRATION AND TOURS.

Charge. The section was in my charge during the whole year.

Establishment. Mr. Jatindranath Sen, the Supernumerary Agricultural Chemist, was posted to work at Sabour from September 1914.

Babu Surendra Lal Das Gupta, M.Sc., was appointed a probationary assistant on 6th February 1915 and he promises to prove a useful addition to the staff.

Babu Debendra Nath Chatterjee has been transferred to the office of the Chemical Examiner and Bacteriologist, United Provinces, from 7th June 1915.

Babu Mahabir Prasad was appointed a probationary assistant from 6th April 1915, but has reverted to the Education Department of the United Provinces.

Mr. G. K. Lele was dismissed in November 1914.

Tours. The following tours were made by me :—

1. September 1st to 9th. To Indore to advise as to the nature of the local soils.
2. September 12th to October 18th. Hill recess, when a memoir on Soil Temperatures was written.
3. November 4th to 20th. Tests of the freezing points of milks were made at the military dairies at Lucknow and Allahabad. I also attended the camp-of-exercise of the United Provinces Horse.
4. December 29th to January 10th. I visited Peshawar in order to test sugarcane at the time it was put into clamps.
5. March 13th to 28th. I visited Peshawar again to test the sugarcane when being taken out of the clamps.

II. Education.

No students have been admitted during the past year.

III. Meteorology.

In addition to the usual records for the Meteorological Department, records of (*a*) soil temperatures, (*b*) drainage, and (*c*) pressure by means of a barograph have been maintained.

IV. Soil Problems.

Soil temperatures. The temperature of the soil is well known to have an important influence on the soil, chemically and physically, but perhaps more especially on its biological activity, both with respect to the higher plant and lower organism. Moreover, since plant growth is principally confined to the upper two or three feet of soil, it is the temperature, and the temperature change, occurring in this stratum which is of importance. Several records of soil temperature have been maintained by the Meteorological and Survey Departments, but these have related rather to the temperature change of considerable depths than to that of the uppermost soil. For these reasons it was decided in 1910 to maintain such a record at Pusa. The soil being a bad conductor of heat, it is to be expected that the chief diurnal temperature changes will occur within the first few inches. It was then evident that for a record of soil temperature to be of service, it must relate to planes near to the soil surface. The nature of the soil-surface had also to be considered. Commonly this is rough, including lumps of earth varying from one to several inches in diameter with open spaces between them. How would such an irregular surface affect a thermometrical instrument? A further primary question was what effect would a growing crop have on soil-temperature changes? It was originally desired to ascertain the temperature changes for exposed soil (*a*) with a plain surface and (*b*) with a rough one, as well as for land bearing crops, but preliminary work showed that the diurnal variation in the first 3″ of soil was so great that an irregularity of 1″ caused

by the presence or absence of any odd piece of earth over the thermometer, would seriously impair the record; that indeed it would be necessary to know the distance from the surface to the instrument to within 0·1″ if the record was to be at all correct with reference to depth below the surface. For example, if two thermometers were placed at a nominal depth of 2″ below the surface, and owing to rough cultivation of the soil above them, the actual depth or thickness of soil were altered to 1·5″ and 2·5″ respectively, these two instruments instead of registering the same temperature, say at midday, would actually show a difference of more than 1° C. The rough cultivation commonly employed throughout India in the hot weather, which has been styled "hot weather weathering," implies a surface much more irregular than that just exemplified, and it was almost immediately clear that any record which was maintained below a roughly cultivated surface would be valueless because of the impossibility to define the distance from the surface to the instrument. The records maintained at Pusa have referred to the soil below (*i*) a smooth bare-fallow surface, and (*ii*) a similar surface on which crops were growing. The instruments employed were self-registering mercurial and alcohol thermometers of a good make, the errors being determined periodically. They were placed in tubes running horizontally below the soil surface at 1″, 2″, 3″, 6″, 9″, 12″, 18″, and 24″ deep. This arrangement is not what has been usual when observing soil temperatures, instruments being commonly inserted vertically into the soil. The latter is open to criticism in several respects; the instruments are exposed to the sun, they will generally possess a different, and often greater conductivity than the soil; the thermometer bulbs or sensitive part of a pyrometer indicates the mean temperature of the soil stratum in which it rests, and not that of a plain which is actually what is desired; if then the instrument is placed horizontally, this soil stratum is considerably thinner than if it is placed vertically in the soil, that is, this source of error is reduced.

The information has been published as a *Memoir of the Department of Agriculture in India* (*Chemical Series*, Vol. IV, No. 2) and the principal items of information are as follows :—

(*a*) *In bare-fallow soil.* (*i*) There are naturally both diurnal and seasonal changes of temperature. The former extends to between 1 ft. and 2 ft. from the surface; at 1 ft. deep it amounts about 1° C., but at 2 ft. it is doubtful whether it ever exceeds 0·1° C. in Bihar and probably never exceeds 0·2° C. in any part of India. Near the surface the diurnal change is very considerable. The seasonal change at 2 ft. deep amounts to about 13° C. The minimum temperature occurs in January and the maximum in May.

(*ii*) There is a fairly close correspondence between the soil temperature at 1″ deep, in bare-fallow soil, and the air (shade) temperature; approximately the soil-minimum is 2° higher and the soil-maximum 3° higher than the air temperature.

(*iii*) There is a similar relation between the *diurnal change* of temperature in the soil and air; at 1″ deep this change is about 1·5° C. greater in the soil than in the air. This diurnal change is least during the monsoon and greatest during the dry season, as is the case in the air. The amount of the change varies from 10° C. to 20° C.

(*iv*) Regarding the soil-temperature *at* the surface this could not be ascertained directly, but judging by collateral evidence, with a clear sky it probably rises to about 20° C. higher than the air (shade) maximum temperature during the day, and falls to approximately the air minimum at night.

(*v*) The above relations are substantially independent of season, and since the range of temperatures at Pusa is considerable, it seems reasonable to

conclude that they would apply to soils generally in India.

(*vi*) The temperature of the soil near the surface, (down to 3″ or 4″) is above the mean temperature for only about 8 hours and below it for about 16 hours.

(*vii*) The lag in temperature change is about 2 hours at 3″ deep and about 8 hours at 18″ deep.

(*viii*) A change in the specific heat and conductivity of the soil due to change of proportion of water, does not always affect the maxima and minima. During the monsoon period when the soil contains very much more water than during the dry season, and when both its specific heat and conductivity are consequently very much greater, the relation between soil temperature and air (shade) temperature remains substantially unaltered. That a wet soil requires considerably more heat to raise its temperature 1° C. than does a dry soil is of course well understood, but apparently the period of exposure is sufficiently great to allow the soil's temperature to assume during the day or the night the same relation to the air temperature whether it is wet or dry; the effect of increased conductivity counterbalancing that of increased specific heat. If, however, a heavy shower of rain falls on the desiccated soil of the hot weather, the conditions are different. Such showers are accompanied by a marked fall of air maximum temperature and the soil-maximum falls in a corresponding degree. But the air humidity at this season rapidly falls after such showers and evaporation of moisture from the soil increases very greatly, causing a marked change in the soil-minimum.

(*b*) *In cropped land.* The effect of a covering crop on the soil-temperature is naturally very marked,

for it both prevents the surface soil from rising to the temperature which fallow land assumes, and also modifies the diurnal change. Thus whilst the temperature of exposed soil at 1″ deep rises to about 3° C. *above* that of the air, that of cropped land is about 2° C. below it; and whilst the temperature of exposed soil *at the surface* rises to probably some 20° C. above that of the air, the corresponding figure for cropped land is only some 2° or 3° C. even in March, whilst in the rains it is actually lower than the air. Also in respect of diurnal change; at 1″ deep, whilst exposed soil suffers a change of some 20° C. in March, that of cropped land is only about 13° C. at the same depth; and during the monsoon whilst exposed soil suffers a diurnal change of some 10° C. at 1″ deep, that of cropped land is only about 3° to 4° C.

Soil gases. For some time attempts have been made at Pusa to devise an apparatus by the aid of which the gases contained in a portion of undisturbed soil, taken from a specified depth, might be extracted, measured and analysed. Hitherto the gases contained in soils have been separated for analysis by inserting a tube into the soil and aspirating a portion of gas out of it. By this latter method contamination with the outside air is possible, the real situation from which the gases flow into the tube is uncertain, and the direct measurement of the gas per unit volume of soil is impossible. But if a portion of undisturbed soil could be taken from the field in a tool which could be subsequently closed and provision made for attaching this to a pump, the volume of gas so obtained could be compared with the volume of the soil specimen taken from a specified depth and contamination with atmospheric air would be excluded. Although an apparatus for this purpose was designed several years ago and employed on some preliminary work on soil gases, it was not free from imperfec-

tions, and the more perfect one which has been employed for recent investigations was only designed and made in 1913. By its aid the gases contained in a known volume of soil taken from a specified depth below the surface can be separated, measured and analysed.

One of the first questions that occurs is whether a finely divided material like a soil condenses much gas on its surface. A volume of soil will include mineral and organic matter, water and gases. The volume of soil in the apparatus above referred to can be measured; the volumes of the solid material, and of the water can be derived from their weight and density, that of the gas which is extracted can be measured. Some of the latter will be in solution in the water, but the volume of this can be calculated. Thus these various measurements yield on the one hand the volume of the soil; on the other the volumes of solid material, water, gases. If there were no condensation of gas by the soil material, the sum of the latter would equal the volume of the soil *in situ*. But if the soil material is able to condense gases, the sum of the several constituents will exceed that of the soil. The measurements are naturally accompanied by some errors and it is not possible to say that the Pusa soil condenses no gas, but the proportion is certainly very small and is less than 4 per cent. of the total gas present.

The amount of gas which the water in the soil dissolves is of great interest. In dry land soils, the only gas which dissolves to any material extent is carbon dioxide, the volumes of dissolved oxygen and nitrogen being too small to be of any consequence. By the aid of the work[1] on the bicarbonates of calcium and magnesium which was done in this laboratory by myself and Mr. Sen, it is possible to calculate how much of the carbon dioxide is dissolved and in the gaseous state in the soil respectively. In fallow soil in all ordinary conditions very much the greater part of the carbon dioxide is in the dissolved state.

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[1] *Mem. Dept. Agric. Ind.*, vol. I, no. 7, and vol. III, no. 8.

In the case of swamp paddy soil gases, the amount of dissolved oxygen and nitrogen has an important bearing. Messrs. Harrison and Subramania Aiyer have given reasons[1] for assuming that the dissolved oxygen is of importance both to the surface film and to the roots of the plant below. Calculations regarding the sources of the nitrogen in the gases have shown that probably about one-third of it is derived from the dissolved nitrogen of the irrigation water.

Regarding the examination of soil gases generally it is of importance not merely to ascertain the proportions of oxygen and carbon dioxide present. Although our knowledge of the biology of the soil is so imperfect, the general conclusion that oxygen is commonly used up in the production of carbon dioxide is no doubt justified, but the ordinary gas analysis might not show whether oxygen was being utilized in other ways. Again percentages of oxygen and nitrogen do not themselves show whether there has been an absorption of the one or an evolution of the other. For example supposing nitrogen gas were being liberated the effect would be an increased per cent. N, a decreased per cent. O; but these figures would not show whether oxygen was being absorbed by the soil or nitrogen liberated. An important case of this nature is the origin of the nitrogen in paddy land gases. Messrs. Harrison and Subramania Aiyer after discussing the matter[2] by means of indirect evidence, concluded that a part of the nitrogen in these gases was derived from the organic matters of the soil and manure, but a means of directly testing the question was clearly of importance. Such a question could be solved by the estimation of a gaseous element which takes no part in biological processes. The gases present in the soil are derived from (*i*) the outside atmosphere and (*ii*) the products of biochemical change. Hence if the nitrogen in the soil were derived solely from the atmosphere, its ratio to the rarer elements, argon, helium, etc., in the soil gases should be the same as in the atmosphere, whilst if nitrogen

[1] *Mem. Dept. Agric. Ind.*, vol. III, no. 3, p. 81.
[2] *Loc. cit.*, p. 82.

gas were being produced from organic matters or if it were being assimilated by a plant, its ratio to the rarer elements would be altered. The estimation of the proportion of argon in soil gases offered a probable solution of some of the above indicated questions. Argon takes no part in animal or vegetable economy, and except for very slight possible alterations due to diffusion, its ratio to oxygen and nitrogen in the soil would be the same as that in the air, unless these latter gases were absorbed or liberated during biochemical change. The atmosphere contains only 0·93 per cent. A against about 79 per cent. N, and since the accuracy of the estimation of the one depends on that of the other, the probable error in the ratio is not inconsiderable, but nevertheless as an aid to the examination of soil gases, the argon determination has proved of great use.

Mr. Harrison very kindly sent me samples of the gases obtained from paddy lands and the result of the analyses was to show quite conclusively that nitrogen gas is liberated in these lands from the organic matters. The N : A ratio in atmospheric air is 83, whilst those found in the paddy land gas varied from 92 to 98. Moreover it has to be realized that the outside air is so perfectly excluded that, apart from any nitrogen evolution in the soil, the nitrogen and argon in these gases are largely derived from the dissolved gases in the water, in which the N : A ratio is 33. Hence the conclusion was admissible that a high proportion of the nitrogen in these gases is derived from the decomposition of the organic matters.

In other cases the N : A ratio has not proved so serviceable as was at first hoped. The assimilation of nitrogen gas by *Papilionaceæ* is a case in point. It is usually assumed that the assimilation, by these plants of a part of their nitrogen is effected indirectly by the agency of the bacterium, *Bac. radicicola* in the root nodules, but the assumption lacks direct experimental proof. Allowing the truth of the assumption, then the N : A ratio would fall in the gases present in the neighbourhood of the roots of such plants. As a matter of fact nearly all the N : A ratios

found for samples of such gases were low, but unfortunately it is not possible to determine this ratio very precisely, and the difference actually found had to be referred to probable error. In addition, subsequent considerations of the quantities of nitrogen involved indicated that it is doubtful if the question of the assimilation of this element by the roots of *Papilionaceæ* can be solved by the N : A ratio.

Another question naturally arises, namely, whether other gases than carbon dioxide or nitrogen are produced in soils? The gases of swamp rice-land include much hydrogen and methane, but the conditions are anaerobic and the general opinion has been that in ordinary dry-land soils such gases would not be produced. For example recent samples of gases from Rothamsted soils[1] were found to be free, or substantially free, from hydrogen and hydrocarbons. In some of the Pusa soil gases small, though well defined, amounts of hydrogen were present. This was the case particularly in the neighbourhood of the roots of crops, san hemp, indigo, maize, and must be referred to bacterial activity. In the same situations very large proportions, 16 to 20 per cent., of carbon dioxide, and low proportions—2 to 4 per cent.—of oxygen were found. Such proportions of these gases have not been met with elsewhere in the neighbourhood of crops, but it is to be recollected that the subject is one which has been hardly investigated hitherto and indicates a very intensive activity of lower organisms at least during the monsoon in India.

The conditions during a period of rapid nitrate formation are again very interesting. When discussing the drainage of rain water through soils,[2] evidence was adduced showing that intensive nitrification in the first few inches of soil followed immediately after the first heavy rain of the monsoon, in 1910; this occurred similarly in 1911 and 1914. During this process considerable amounts of oxygen are required, and calculation showed that this

[1] *Jour. Agric. Sci.*, VII, 4.

[2] *Mem. Dept. Agric. Ind., Chemical Series*, vol. II, no. 2.

oxygen could hardly be accounted for by that which was present in the soil. Other experiments showed that this soil utilizes under such conditions even much more oxygen than that required for the nitrate formation. On the other hand analyses of the gases in 1914 showed that despite the large amount of oxygen required, the percentage of this element in the soil was nearly normal. It became evident therefore that a sufficient supply of oxygen must have been diffusing into the soil from the atmosphere.

The process of diffusion of gases through soils has been generally believed to be a very slow one. Direct experimental evidence on the subject is limited to that of E. Buckingham[1] who concluded that there was a direct relation between the "porosity" of a soil and the rate at which gases could diffuse through it. The "porosity" he defined as that fraction of the whole volume of soil which is occupied by gases. He defined any particular portion of soil as unity and the "porosity" is therefore less than unity. Soils commonly include as gas some 20 to 40 per cent. of their volume, and the "porosity" in such cases varies from 0·2 to 0·4. Buckingham considered that the equation :

$$D = K\ S^2$$

was sufficiently accurate to define the quantity of a gas diffusing through a known column, (or depth) of soil, under known gradient; and that this quantity is less than would diffuse if no soil were present by the square of the porosity. The results of such experimental work should, if possible, be checked by independent evidence, but the difficulty is to provide such independent evidence.

Buckingham's equation was applied to several of the cases which have formed the subject of the work on soil gases at Pusa, and in some respects at least it is supported. For example where green manure was applied during the monsoon, the calculation showed that 0·0658 c. dm. of CO_2 was leaving the soil per sq. dm. per day during the first 10

[1] Contributions to our knowledge of the aeration of soils by E. Buckingham; *U. S. Dept. Agri. Bur. soils, Bull.* no. 25, Washington, 1904.

days. Assuming a uniform rate of decomposition, the whole of the green manure would be oxidized in about 95 days. There is, however, reason to suppose that the rate would fall off as time went on, so that as an independent test of the reliability of the equation, it may be considered to support it very well. Again the calculated amount of carbon dioxide production in soils in which nitrification was in progress agreed very fairly with what was experimentally determined under controlled conditions in the laboratory. On the other hand calculations for the volumes of oxygen diffusing into the soil yielded unexpectedly high figures. One cannot go further with the matter at present, but it is at least certain that the process is a much more rapid one than is commonly supposed.

The value of good cultivation of the surface soil has been usually attributed to the fact that by stirring the soil, gaseous interchange is suitably accelerated, carbon dioxide is allowed to escape and oxygen to enter. It is often easy to suggest an explanation which on paper bears the necessary "hall-mark," but it is somewhat remarkable that among the many who have accepted this explanation for the advantage of good cultivation, none appears to have considered that much deeper stratum of soil—several feet in thickness—which is never disturbed by cultivating implements but in which crop roots develop freely and which it is equally necessary to aerate. If for efficient gaseous interchange it is necessary to plough the top 6″, it should be similarly necessary to plough the succeeding several feet of soil! So long as one is content to accept the proved value of good cultivation without attempting to give explanations for its advantage, the position is unassailable; but if one goes further and states that the explanation is that thereby objectionable carbonic acid is released from or valuable oxygen admitted into the soil, the premises are very readily open to criticism. Even allowing Buckingham's experimental work to have been a good deal in error, the consideration of the cases which have been examined at Pusa shows that, so far as aeration is concerned, the culti-

vation of the surface soil might be omitted altogether; its well established value must be referred to other causes.

A memoir on the subject is now in the press.

V. Manures.

Village ashes. Owing to the war the supply of potash salts from Stassfurt has ceased and since these mines have formed the chief source of the world's potash supply for a number of decades, the price of all potash salts has risen seriously.

India is not a large consumer of potash salts, but there is a small steady demand for such among the tea and coffee planters of Southern India, and it was thought to be worth while to examine samples of village ashes obtained from the several provinces in order to ascertain whether potash could be economically extracted from them. Seventeen samples were examined and the percentage of potash varied from about 1 to 10 per cent. From one quarter to two-thirds of this is frequently soluble in water. The remainder could be extracted by the agency of strong acid, but this could not possibly pay. The water soluble potash could be readily and very cheaply extracted in a manner similar to that employed for the extraction of saltpetre from earths. The evaporation of the water, in order to obtain the crude potash salt, would require relatively a good deal more fuel than is required for the evaporation of the crude saltpetre liquors, and since the crude potash salts obtained per 100 lb. of water evaporated would not be worth nearly as much as the corresponding quantity of crude saltpetre, and since also the latter operation hardly pays the *nuniah* to continue his industry, I concluded that it is very doubtful if the manufacture of crude potash salt from village ashes could succeed.

It seems probable that tea and coffee planters who require potash salts could most readily supply the present deficiency by either burning waste timber on their own estates or by doing so in the nearest forest, and putting the wood ashes direct on the land, or possibly after first

treating the ashes with a limited amount of sulphuric acid. A note has been submitted on this subject.[1]

VI. Saltpetre.

The experiments on the improvement in methods for refining saltpetre have progressed considerably during the past year and there is now every reason to hope that by the use of a filter press and other appliances the outturn of refined saltpetre will be considerably greater than is usually obtained by refiners.

VII. Feeding Stuffs.

A considerable number of specimens of cattle foods have been analysed during the year more particularly on behalf of the military authorities. It is intended to issue these and other analyses shortly in the form of a bulletin.

VIII. Sugar.

Sugarcane. The nature of the sugar investigations which have been in progress during the past three years at Tarnab, Peshawar, was explained at length in my last annual report. The only additional work which has been done during the past year consisted in a test, on a large scale, of the safety of "clamping" large quantities of sugarcane. It will be recollected that from the manufacturing point of view the advantage of being possibly able to preserve sugarcane over the months of February to April was recognized and experiments with small lots of sugarcane were made during the cold weather of 1913-14. These indicated that the local sugarcane could be so preserved until at least sometime in March without suffering serious depreciation. It had to be recognized, however, that in order to draw a safe deduction the tests should be made with large quantities of cane such as would probably occur in practice, because the conditions in small heaps would be different in some respects; the weight of cane in a large heap would subject the cane at the bottom to a greater

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[1] *Indian Trade Jour.* July 23rd, 1915.

pressure than would occur in a small heap; the care which could be economically devoted to the handling of a large quantity of cane might not be sufficient to prevent considerable breakage of cane, resulting in a possibly serious amount of rotting; it was also desirable to estimate the cost of clamping.

Accordingly Mr. Robertson Brown arranged to calmp two lots of sugarcane in January, the one from approximately an acre and weighing about 20 tons, the other from half an acre and weighing about 16 tons. The former was "striped Mauritius," the latter "local *pounda*" cane. These two lots of cane were put into the clamps during the 1st week of January and the clamps were opened and tested during the third week of March, that is after a period of about 10 weeks. In the following table the chief data are set out, from which it will be seen that the amount of change suffered by the cane was nominal.

—	Striped Mauritius		Local *pounda*	
	January	March	January	March
Weight per cane (lb.)	1·74	1·79	1·78	1·91
Juice per cent.	71·6	65·7	73·1	71·1
Sucrose per 100 parts of juice	13·19	12·11	12·34	11·20
Invert sugar per 100 parts of juice	0·83	0·73	1·29	1·04
Brix	16·1	14·8	15·3	14·5
Co-efficient of purity	84·7	84·6	83·6	81·5

These two experiments leave no doubt that sugarcane can be safely preserved in clamps until the end of March at Peshawar without suffering any serious loss. The number of canes which rotted in the clamp was very small; rotting was quite definitely restricted to cane which had been accidentally cut or broken and did not extend beyond the originally damaged part, nor did it spread to sound cane. No sound cane was damaged at all.

Mr. Robertson Brown and the writer have discussed the practicability of employing this process on the large scale for the advantage of a factory. There is no doubt that it is rather more troublesome to take cane up by the roots than to cut it off; there is also the cost of putting the cane into clamps, and the cost of taking it out again. Altogether apparently this increased cost would come to about one anna per maund of cane. On the other hand it is to be realized that a factory situated in this part of India could certainly afford to pay somewhat more for cane in February and March rather than stop working altogether, for in the latter event the whole of the more expensive staff is kept idle and the daily paid labour becomes dispersed. It is therefore by no means necessarily the case that because it costs something to put cane into clamps, it would not pay everyone concerned to employ the process.

Estimates were obtained during the year for a small sugar factory fitted for working beet and cane and capable of producing from 1 to 2 tons of sugar per day. These were submitted to the Agricultural Officer, North-West Frontier Province. Briefly the factory would cost about Rs. 1,50,000 erected; the annual running charges would come to :—

	Rs.
Wages, etc.	10,000
Cost of 900 tons of cane	9,150
Cost of 900 tons of beet	10,800
	29,950

whilst the value of sugar produced (155 tons) would be about Rs. 33,480. The total sugar annually imported into the North-West Frontier Province is about 9,000 tons which is either consumed locally or re-exported to other frontier countries. Some of this sugar could be easily grown and manufactured locally without in any way seriously affecting the local production of *gur*, which is considerably greater, namely, about 35,000 tons.

Cocoa-nut "milk." At the request of the Chief Commissioner of the Andamans and Nicobar Islands the milk of cocoa-nuts was examined with a view to ascertaining whether it possesses potential commercial possibilities. About twelve lakhs of nuts are utilized annually in the Jail, but for the milk there is no commercial outlet and it is thrown away. It is only a weak solution of sugars and other carbohydrates with small amounts of proteids. The sample sent to Pusa contained 0·187lb. sucrose, 0·056lb. glucose and 0·258lb. of other matters, mostly gums, per gallon of the milk. Boiled down to the dry state it formed a very pleasant tasting "toffee," but it could not possibly pay to conduct this process on the manufacturing scale.

IX. Starch.

During the year my attention has been directed to the possibility of economically manufacturing starch from Indian materials. One of the results of the war has been to cut off some of the usual sources of manufactured starch, resulting in enhanced prices.

The process involved in starch manufacture is extremely simple, but in order to be financially successful the raw material must be cheap and the factory machinery both efficient and well run. This implies expensive management which can only be economically applied for large quantities of starch.

Among Indian raw materials which could possibly fulfil the requirements of the industry, is the sweet potato, (*Ipomoea batatas*,) which is cultivated widely in Bihar, yields well per acre at small cost, comes into the market at several different seasons and some varieties contain upwards of 20 per cent. starch. Experiments have therefore been commenced on the subject of starch manufacture generally and primarily from this material in particular. A very good quality of "farina" can be readily prepared from it.

X. Milk.

Detection of added water in milk. The value of the freezing point of milk as a means of detecting added water was referred to in my last annual report. It was there explained that the value of the test could only be given serious weight after determining the freezing point of a considerable number of milks of known purity, and if the variation were then found to be sufficiently small.

I took the opportunity when on tour to apply the test to a further number of milks at dairy farms, and although the variation of freezing point among milks of Indian cattle is greater than has been found elsewhere, there is no doubt that it forms a much more delicate test for added water than those hitherto employed. It is proposed to publish a note on the subject shortly.

XI. Programme of work for 1915-16.

Major subjects :—

1. Records of the amount and nature of drainage water from fallow land, and land bearing crops are maintained.

2. Experiments on possible improvements in the refining of saltpetre will be continued.

3. The relation between the transpiration of water by plants and the assimilation of plant material during the period of growth will be examined.

4. An examination of the proportion of starch in some of the Indian starch producing crops will be made and their possible utility from the manufacturing standpoint will be considered.

Minor subjects :—

None.

XII. Publications.

1. Indian Village Ashes as a Source of Crude Potash Salts, by J. Walter Leather. *The Indian Trade Journal, xxxviii, p. 132.*

REPORT OF THE IMPERIAL ECONOMIC BOTANISTS.

(A. Howard, C.I.E., M.A. and Gabrielle L. C. Howard, M.A.).

I. Introduction.

The Imperial Economic Botanist held charge of the section during the year under review. On February 10th, 1915, the Personal Assistant was promoted by the Secretary of State, on the recommendation of the Government of India, to the post of Second Imperial Economic Botanist.

The work of the staff continues to be satisfactory. The post of Fourth Assistant was filled by the appointment of Chowdhri Ram Dhan Singh, who was confirmed after twelve months' service as a probationer. The good work of the Second Assistant, Maulvi Abdur Rahman Khan, was rewarded during the year by a substantial increase in pay. At Quetta, Overseer Chandu Lall has made satisfactory progress.

Two advanced students, from Bombay and Bengal respectively, worked for a session in the section. The former then proceeded to England, having obtained a scholarship for three years for plant-breeding work; the latter has been recommended for trial in the Bengal Agricultural Department as a probationer.

II. Investigations at Pusa.

Wheat. *Pusa 12.* In the last report, a detailed account was given of the successful trials by cultivators of Pusa 12 in the chief wheat-growing provinces of India and of the initial steps contemplated in the establishment, on a commercial scale, of an improved grade of white wheat. During the year under review, considerable progress has

been made in both these directions and important results have been obtained.

In connection with the trials of Pusa 12 by the ryots in the various wheat-growing areas, the results obtained in the United Provinces are perhaps the most important. The season in these provinces was not a very favourable one for wheat. The rains ceased early and, in many Districts, the crop had to be sown in too warm a seed-bed. The winter rains were late and although there was a marked improvement in February, this was speedily followed by long continued wet weather which brought on rust and seriously diminished the yield. Under these adverse conditions, Pusa 12 did well and stood out conspicuously from the country wheats. The general results are thus summed up by the Director of Agriculture in "United Provinces Agricultural Notes for March, 1915" which appeared in the *Pioneer* of April 11th last.

"Pusa No. 12 wheat, of which a considerable area is now grown over different parts of the Provinces, has done well everywhere. It has shown itself relatively rust-resisting, and has given a good yield even in the worst affected districts. This feature has attracted particular attention in a year like the present, and there is little doubt about its rapid spread in future."

In the previous wheat year, 1913-14, a season of short moisture, Pusa 12 did much better than the country wheats as it was able to ripen a good crop with comparatively little moisture. Shortness of moisture during the growth period, the early cessation of the rains (leading to a warm seed-bed and subsequent liability of the seedlings to wither and to be destroyed by white ants) and long continued wet weather after the crop comes into ear (giving rise to serious attacks of rust) are the chief factors which limit the yield of wheat in the Gangetic alluvium. From the point of view of the testing of a new variety in this tract, the two seasons, 1913-14 and 1914-15, have been very favourable ones as, in both cases, adverse factors have been experienced. In both years, Pusa 12 has shown a

marked superiority over the local wheats and these facts must be regarded as of the greatest promise for the future of this variety.

During the year, the best yield of Pusa 12 so far reported was that obtained by Mr. Clarke at the new Sugarcane Experiment Station at Shahjahanpur, where over 500 maunds of seed were obtained from an area of 16½ acres, although a portion of this was badly lodged by rain and wind just after the crop came into ear. This outturn is over 30 maunds or 40 bushels an acre. Very good returns were also obtained on the private farms of the Taluqdars of Oudh as well as in other parts of the Provinces. The results clearly show that it is possible to produce in India wheats which combine both high yield and good quality when grown by the people themselves.

Progress has been made in the work relating to the shipment of Pusa 12 for trial by the Millers of the United Kingdom. This side of the work is being carried out in the Central Circle of the United Provinces with the co-operation of Mr. B. C. Burt, Deputy Director of Agriculture, who is working to replace the country wheats by Pusa 12 from certain centres near Cawnpore. The surplus will be bought up by Government and shipped by Messrs. Ralli Brothers who, with Mr. Humphries, have undertaken to bring this wheat to the notice of the Home Millers so that they may have an opportunity of getting first hand experience of its qualities and behaviour. In the District work, the Co-operative Credit movement has been utilized as well as Court of Wards' estates and large *zamindars*. In spite of the shortness of seed from Bihar and the disinclination of the ryots to sell their surplus produce, a beginning has been made during the present year and the first parcel was sent to London in June last. In 1916, it is hoped to send larger quantities and to organize the work in such a manner that certain of the local wheat markets will in time be able to supply pure Pusa 12 to the shippers. The work in the Central Circle of the United Provinces in attempting to replace a country crop by a

new variety of better quality is an important undertaking which, if successful, will be a distinct step in advance. Up to the present, what has been done has been to produce improved wheats and to test them under cultivators' conditions. The next stage is to replace the country crop by the new kind and, while this is in progress, to convince the Home Millers that India can produce much more valuable wheats than those now exported. Once a large area is completely replaced, the wheat trade can supply itself and fraudulent admixture with local wheat will be rendered difficult.

Besides Pusa 12, two other new wheats, No. 4 and No. 6, are proving useful in certain parts of India. Where the supply of soil moisture is limited and where the general conditions require a rapidly maturing wheat, Pusa 4 is meeting a long-felt want. This variety possesses strong straw, good grain and is also practically immune to yellow rust. In Bundelkhand, it is being successfully distributed to the cultivators by Mr. Burt. As a cover crop for Java indigo in Bihar, this variety is also likely to be of use. The kind, however, which appears to suit Bihar best as a single crop is No. 6, which for the last few years has done exceedingly well on the Belsund estate. It is practically immune to both the common rusts in Bihar and seems to thrive even under adverse conditions. With the spread of drainage in Bihar, it will be possible to extend the cultivation of wheat and to make sure of a fair crop even in unfavourable seasons.

In addition to the results obtained in India, the new Pusa wheats have been tried with success in other countries. In the Argentine, where the ordinary crop is often damaged by hot winds before harvest, Pusa 12 and Pusa 4 have given good results and a stock of seed is being worked up for distribution on the Government farms. Equally favourable reports have been obtained from Australia and the Sudan. It seems probable that, in addition to India, Pusa will prove of use as a wheat-breeding station for the warmer wheat-growing areas of the world.

Wheat-breeding. Considerable progress has been made during the year in still further improving Indian wheats in the direction of increased rust-resistance, better standing power and higher yield. The past year has been perhaps the worst for wheat so far experienced at Pusa. The root development was poor, due to the warmth of the sub-soil, and, after the crop came into ear, the wet weather was followed by an epidemic of rust. Notwithstanding these adverse conditions, a good many of the cultures were not affected by either of the three rust fungi which attack wheat in Bihar. These new wheats are now in the fifth generation and are practically fixed.

Tobacco. The demand for seed of the cigarette tobacco, Type 28, continues to increase and a large quantity was distributed during the year. It will be necessary to raise still larger quantities of this seed in future years to meet the ever increasing demand. The seed was cleaned and separated into two grades before issue by a special machine on the principle of a corn dresser. All light and poorly matured seeds are removed and the resulting seedlings are stronger and more robust than those raised from ordinary untreated seed. The tobacco seed is so minute that only those individuals which are heavy and well filled contain sufficient reserve material for producing rapidly-growing seedlings.

During the year, the practical results obtained in the cultivation and curing of tobacco were published as a bulletin. These have been referred to in previous reports and it is unnecessary to repeat them here. The experiments connected with improved methods of raising tobacco seedlings and with green-manuring for this crop are being continued.

Progress has been made during the year in tobacco breeding and in the study of the inheritance of characters in both *N. tabacum* and *N. rustica.*

Indigo. A considerable amount of progress was made in the indigo investigations which enabled definite recom-

mendations to be placed before the planting community. A study of the so-called wilt disease, which has been responsible for the great diminution of area under Java indigo in Bihar in recent years, led to the realization of the important part played by the root nodules in the general economy of the plant and also in the production of indican. This in turn made it possible to perceive the factors on which the yield of indigo depends and to work out improved methods of production both of indigo and of indigo seed.

Indigo wilt was found to be the last phase in a starvation process which always takes place in this crop when the work of the root nodules is seriously interrupted. Wilt may be produced in two quite different ways. In the first place, when indigo has been subjected to long continued wet weather, resulting in a waterlogged condition of the ground and in an insufficient supply of air for the roots and nodules, the plants cease to thrive, growth slows down and the characteristic unhealthy foliage associated with wilt is produced. Such plants die slowly without setting seed and when the wilted condition has been reached are found to have lost most of their nodules and feeding roots. In the second place, wilt is produced in healthy plants growing in soil where there is plenty of air and moisture, when the nodules are suddenly deprived of their food supply. If rapidly growing Java indigo, sown in August for seed, is cut down to the ground in October, most of the plants die and only a few make fresh growth. In the majority of cases, this new growth is wilted and such plants maintain themselves during the cold weather with the greatest difficulty. Examination of the roots, soon after the cutting back, shows that the nodules are in a moribund condition. These results enabled improved methods of cultivation and of seed-growing to be devised, which were immediately tried and found successful on the indigo estates themselves.

The secret of success in the cultivation and management of both Java and Sumatrana indigo has been found

to be efficient surface cultivation in the hot weather combined with drainage in the monsoon. The hot weather cultivation, for which suitable implements have been introduced into Bihar, enables the crop to obtain an ample air supply and also leads to the destruction of weeds and to a great saving in the cost of production. Surface drainage on the Pusa system, by preventing the flow of surplus rain water over the indigo fields, assists in maintaining the essential air supply to the roots and nodules and so tends to increase the growth and to prevent wilt. The adoption of these methods on the Dholi estate for the 1914 crop led to a record yield both of finished indigo and of *seeth.*

The discovery of the nature of the wilt disease also led to a method of growing the seed of Java indigo which is rapidly being taken up all over Bihar. Formerly, the old indigo crop was kept over the cold weather and seed was collected from these plants. This placed the planters at the mercy of the season as, in many cases, the crop became so weak from wilt that it produced only a small quantity of poor seed. At the same time, very large areas had to be set aside for seed which became very foul with weeds. The new method makes the planter independent of the season and leads to the certain production of well-grown seed from a comparatively small area which can easily be kept in a clean condition. For seed, Java indigo must be sown in early August in high-lying, well-drained fields which are in good condition. The plants must be well-cultivated and properly spaced so that they grow rapidly and come into flower towards the end of October. At this period, the weather is warm and dry, bees are abundant and all the conditions for pollination are present. This method was adopted on the Dholi estate for the 1915 harvest when a very fine crop of seed of over eleven maunds to the acre was obtained. The land was afterwards kept through the hot weather and yielded crops of leaf in the ordinary way.

The provision of a better cover crop for Java indigo has enabled several estates in Bihar to reduce the cost of

cultivation. A new variety of wheat, Pusa 4, has been introduced which can be grown with indigo on high lands. This wheat is a rapid grower, does not tiller much, has a strong straw and is provided with few leaves. On this account, the young indigo plants get a full supply of light and air and the two crops do very well together. It is hoped later on, when this new wheat spreads, to establish a grade for the Calcutta market.

Among the items of investigation now in progress with regard to indigo may be mentioned the selection work on Java and Sumatrana and the experiments devised to increase the efficiency of *seeth* as a manure. New varieties of Sumatrana and Java indigo are being tried this year on an estate scale and the results will be dealt with later. Evidence has been obtained that a part of the value of *seeth* in tobacco growing is its power of aerating the soil and of providing the soil organisms and the roots of the tobacco with an adequate supply of air. If this is confirmed, *seeth* can probably be made to go further by adding the proper proportion of broken tiles (*thikara*) to the soil.

The progress that has already been made in the indigo investigations indicates that the prospects of resuscitating the industry are very favourable. The competition of the synthetic product has, for the time, been removed, a period of high prices has set in which will be the means of establishing confidence and of putting the estates which are growing indigo into order. The value of the industry to Bihar agriculture is considerable. *Seeth* is an excellent manure and the part played by the Java plant in the rotation in aerating the subsoil is much greater than is commonly realized. Apart from all the other aspects of indigo growing, the industry is well worth saving from the point of view of the welfare of the people and of the maintenance of the fertility of the soil.

Gram. For some years, a botanical study of the varieties of gram, cultivated in India, has been in progress at Pusa and a good deal of work has been done on the general requirements of this crop as regards soil and culti-

vation. A considerable volume of results has been obtained which has now been arranged for publication. As in Java indigo, the well-being of the crop depends to a very large extent on the physical condition of the soil and on a copious supply of air to the nodules and roots. The results obtained, on different classes of soil in the Botanical area, explain both the present geographical distribution of gram in India as well as the dependence of the yield of seed on the season. The two chief climatic conditions which limit the yield are heavy rains, which produce surface crusts and deprive the roots of air, and damp weather at flowering time which interferes with pollination. Self-pollination is the rule in gram at Pusa but instances of natural crossing occasionally occur. Twenty-five types, differing widely in habit and yielding-power, have been isolated which are now being tested for yield under varying conditions. One interesting fact has already come out of these variety trials, namely, the union of high yield and good quality in the same variety. Type 9, grown at Pusa for the last four years on a large scale, on widely varying soils and in very different seasons, has given an average yield of just over twenty maunds per acre. This is the second highest average outturn, the best being that of twenty maunds thirty-three seers yielded by Type 18. Taking both yield and quality into consideration, however, and on the basis of the valuation of Messrs. Ralli Brothers, Type 9 gave the best return, an average of Rs. 78-11-0 per acre while the average produce of Type 18, the highest yielder, was worth only Rs. 61-4-0 per acre. This result is another illustration of the value of selection methods in improving Indian crops in the present condition of agriculture in this country. Had an attempt been made by hybridization methods to achieve such a union of yielding power and grain quality, the work entailed would have been arduous and long continued.

Fibres. In 1910, a study of the varieties of *patwa* (*Hibiscus cannabinus*) was completed at Pusa when it was observed that one of the kinds, Type 3, appeared to be much more suitable for cultivation than any of the others. In

the account of this work published in 1911 (*Mem. Dept. of Agr. in India, Botanical Series*, Vol. IV, No. 2), mention was made of a possible method of keeping cultures of this type pure by removing heterozygotes in the seedling stage. If this could be done in practice, the difficulties with regard to vicinism in the case of a crop in which a good deal of natural crossing takes place, would be surmounted. Since that time, Type 3 has been grown from unprotected seed and every year the plot has been rogued in the seedling stage and again before flowering commenced. In this way, all heterozygotes have been removed and the kind has been kept pure, notwithstanding the many opportunities of crossing which occurred with the other types grown in the Botanical area. A pure seed supply having been obtained and the method of production having stood the test of time, steps were taken to work out the best way of retting and to obtain expert opinion on the produce as compared with the fibre produced locally. By cutting the plant at the proper time and retting it in clean river water, a very fine sample of fibre was produced which was submitted for opinion and valuation to Messrs. Wigglesworth & Co., 82, Fenchurch Street, London, E.C., who valued it at £18 per ton compared with £8 from the locally produced fibre. Messrs. Wigglesworth stated that the sample of Type 3 was "of excellent growth, being 10 to 12 feet long, exceptionally light-coloured, correctly retted and thoroughly cleaned. Judging by the individual stalks, I should conclude that the yield of fibre must have been of quite exceptional weight. The fibre is pure from end to end and is free from root. It is also of good tensile strength and I have no hesitation in pronouncing it the best specimen of fibre from the *Hibiscus cannabinus* plant which has ever been submitted to me. This class of fibre could be sold in almost unlimited quantities."

Great stress was laid by Messrs. Wigglesworth in their report on correct and thorough retting and on the importance of this in connection with manufacture. Their valuation will serve to draw attention once more to the

great increase in value of fibre, such as Deccan and *sann* hemp, which would immediately be obtained if more care were taken in retting and in placing the product on the market in the most suitable form. All this has been pointed out many times before but the fact that a carefully retted sample from India should have made such a favourable impression on the brokers proves how low is the present standard of preparing fibre in this country for the European manufacturers.

Seed of Type 3 can now be obtained at Pusa and trials of this fibre on some of the estates in Bihar are being arranged.

The work on the inheritance of characters in *Hibiscus Sabdariffa* and on *sanai* (*Crotalaria juncea*), referred to in the last report, was continued during the year and considerable progress was made.

Oilseeds. For some time, a botanical study of the oilseeds of India has been in progress at Pusa and the results obtained in the case of two of these crops—safflower (*Carthamus tinctorius*, *L.*) and *rai* (*Brassica juncea*, H. f. & T.), —have been prepared for publication. During the coming year, it is hoped to continue the study of Indian linseed.

Safflower. Both as a source of oil and to some extent of colour, safflower is widely distributed over many parts of India. The crop has been under investigation at Pusa for six years during which period a fairly detailed botanical study has been completed. Form separation has been undertaken, the heterozygotes have been removed and twenty-four different types, covering a considerable morphological range, have been studied in pure culture. The pollination mechanism of the flowers has been investigated as well as the influence of moisture on setting. Self-pollination is the rule in this crop but a fairly large proportion of crossing also takes place. In 1914, when the types were grown next to next in lines, this was proved to be about sixteen per cent.

The distribution of the red colouring matter (carthamin) to the flowers of safflower was found to be complex, indi-

cating the existence of a number of different colour factors. Carthamin is absent altogether in some of the types while in others it is but feebly developed. Dr. Marsden of Madras, who carried out some dyeing tests with the various types, found that the best colour bearing variety was eight times better than the worst. In the percentage of oil in the seeds, the range in values is nothing like so great as in the case of the carthamin content of the faded flowers. With one exception, the percentage of crushed seeds extracted by ether varied from 20·77 to 30·19. Nineteen of the twenty-four types contained over one quarter of their weight of oil. Oil and carthamin content were not found to be antagonistic and in several types high oil and high colour occurred together.

Indian mustard (*rai*). The most interesting feature of this crop, when studied in pure culture, was found to be the extraordinary range in form. One hundred and two pure types were isolated which varied from thirty inches to nearly ten feet in height. Almost every conceivable intermediate form between these extremes was represented and so close was the resemblance that in many cases the types would only be distinguished by the massed habit.

Self-pollination was found to be the rule in *rai* but crossing, to the extent of about fourteen per cent., occurred when the types were grown next to next in lines. The pollination details were found to agree in the main with those previously described in other species of *Brassica.* A certain amount of evidence was obtained on the inheritance of characters in this crop which indicated the existence of numerous factors. Time will not admit of this aspect of the work being continued.

Both in safflower and in *rai*, the results obtained in this study point to the overwhelming importance of selection in the improvement of crops like these in which some crossing takes place and where the range of form is so great. Form separation, if conducted on a broad basis, would almost certainly lead to the isolation of any desired type which could be multiplied at once and distributed to

cultivators. Hybridization work, on the other hand, begun without exhausting the possibilities in selection, might easily prove to be unnecessary even if, after many years of work, it proved successful.

Soil ventilation and drainage. For some time the existence of an important limiting factor in crop production has been suspected in India, namely, the want of sufficient air for the soil organisms and roots of plants. A large number of observations on plant growth have been made at Pusa, at Quetta and in other parts of India which can be most easily explained by a want of proper aeration of the soil. All the evidence obtained, as well as the results of a number of experiments, have been consistent with this view. During the year, a preliminary statement of the case was put forward in Bulletin 52 in which some of the work in progress was outlined. The volume of the gases in the soil is naturally bound up with the amount of water present and this in turn opens up many questions with regard to irrigation and to the saving of water in crop production. The practical applications of the views put forward are many and obvious. In some cases, they have already been translated into practice. The regulation of the air supply of the soil in the case of Java indigo has given important results which have been indicated above under that crop (p. 35). There seems little doubt that the future of the indigo industry in Bihar depends on the copious aeration of the soil in which this crop is grown. In the case of green-manuring in India, soil ventilation appears to be one of the chief factors on which success depends, while in tobacco cultivation in Bihar there is reason to believe that the cost of manuring can be materially reduced if means of permanently aerating the soil are adopted.

Perhaps the most important direction in which the air supply of the soil can be increased in Bihar is by means of surface drainage. A method has been worked out at Pusa and is now in successful operation on several of the estates in Bihar. This consists in dividing up the area

to be drained into areas, of from five to ten acres in extent, by means of a set of trenches, so devised that the surplus rain water is got rid of and, at the same time, soil erosion is prevented. On the Dholi estate, some remarkable results were obtained during the year. In one case, a large area, which previously gave little or no return on account of waterlogging, was so transformed in a single year by surface drainage that it was let out to ryots for chillies at a rent of ninety rupees a bigha, to the manifest advantage both of the cultivators and of the estate. In another case, a portion of the *zerat* which had previously been rendered very infertile by scour was let to tobacco growers, for the first time, at a rent of one hundred and forty rupees a bigha. Similar results have been obtained on other estates and there is little doubt that this improvement, the capital cost of which is not more than two rupees a bigha, will spread rapidly in Bihar. To obtain the best results, however, it will be necessary to study the rivers in North Bihar in detail and to draw up proper drainage maps and working plans. This aspect of the subject has been dealt with in Bulletin 53. The full development of drainage in Bihar is now beyond the means of the Botanical Section and can only be realized by the employment of engineers. Enough has been done, however, to show how much the production of Tirhoot can be improved by increasing the air supply in the soil by surface drainage. Bihar is now the waterlogged garden of India. Drainage would double its production.

III. The Development of the Agriculture of Baluchistan.

The preliminary work connected with the establishment of the fruit and agricultural Experiment Station at Quetta has been described in detail in previous reports. During the past year, the final details connected with the irrigation arrangements and storage of water were completed. In addition, a good many results of practical value were obtained.

Dry farming. The saving of irrigation water in wheat growing in India is one of the problems which is certain to receive, in the future, an increasing amount of attention on the part of the Agricultural Department. Any extension of the area irrigated by the water now available means increased revenue to Government and greater openings for the surplus agricultural population. At the same time, the less water applied per unit area, the smaller is the danger of waterlogging and of interference with the general healthiness of the locality. A study of the wheat crop under irrigation in many parts of India indicates that too much water is often given and that satisfactory crops can be grown with much less than is now applied. This is particularly the case in the Quetta valley, where good crops of wheat are only grown on heavily manured land which receives at least six and sometimes more waterings. These frequent waterings are considered essential, as the crop has to ripen under a rapidly increasing temperature and in a wind-swept area where the humidity is low. The circumstances at Quetta appeared to be exceedingly favourable for experiments in water saving. These have been completed during the year at the new Experiment Station and the results are of more than local interest. It has been found that very satisfactory crops of wheat can be grown on a single irrigation. This is applied to the land during September after which it is cultivated and sown in October. A good germination is obtained and there is ample moisture in the sub-soil for the development of a deep root system during the autumn and winter. After each fall of winter rain or snow, the soil moisture is conserved by harrowing with the Canadian lever harrow and, by the time the crop begins to shoot in March, there is a good deal of moisture left in the ground. There is also an ample supply of air for the roots and crops grown in this way ripen much earlier and better than the ordinary irrigated crop. The wheat thus escapes a good deal of the heat and dry winds of May and June. The yield obtained on an area of 2·85 acres of unmanured land at

Quetta on one irrigation was 47 maunds 24 seers or 16 maunds and 28 seers to the acre—an outturn which compares well with the average of 13½ maunds per acre grown on similar land with six or seven waterings.[1]

In the above experiment, the conditions were not very favourable. The rain which fell during the life of the crop was badly distributed. There was little rain in January and February while the late falls in April formed surface crusts which could not be broken up on account of the height of the crop. A yield of over 16½ maunds to the acre with one irrigation, compared with the average of 13½ maunds with at least six waterings, clearly proves that at the present time large quantities of valuable water are being wasted in growing wheat in the Quetta valley. There is little doubt that the same thing is taking place in the Punjab where the duty of irrigation water could be increased considerably.

Fodder crops. One of the great needs in Baluchistan agriculture at the present time is some crop by means of which the porosity and moisture holding capacity of the soil can be increased. Leguminous fodder crops, which can also be used as green manure, offer a possible solution of this problem and accordingly some attention has been paid to this matter.

Shaftal. The most promising fodder crop suitable for green-manuring purposes so far found at Quetta is Persian clover or *shaftal* (*Trifolium resupinatum*). When sown

[1] The results of numerous crop-cutting experiments in the District are summed up in the *Quetta Pishin Gazetteer* (p. 102) as follows :—

"In Quetta, 75 experiments were made in 1895-96 and the outturn of wheat per acre in irrigated land was found to be 15½ maunds, the highest being 17½ maunds in the Kasi Circle and the lowest 14 maunds in the Baleli and Durrani Circles. Mr. J. A. Crawford, in commenting on the items, remarked that the results of crop experiments were notoriously apt to be high. Further experiments, made in 1903-04, however, showed still higher returns, the average in irrigated and manured land being 24 maunds, 6 seers, and in irrigated land not manured 13½ maunds. In other parts, the average has been found to be as under :—

	Pishin Mds.	Shorarud Mds.	Chaman Mds.
Land irrigated and manured . .	25	15	15
Irrigated land not manured . .	16	12	10
Dry land	5	5	3

in August, under a thin cover crop of maize or *juar*, Persian clover, if properly managed, gives on good land three cuts of green fodder, weighing about 60,000lb. per acre, before the end of the following May. In addition, the last cut can either be ploughed in as a green manure or else kept for seed. The yield, however, is greatly reduced both by overwatering or by failure to cut the crop in time. The beneficial effects on the soil following *shaftal* are very great particularly on the tilth and general fertility. This is now being recognized and a considerable amount of seed was distributed in 1914.

Before *shaftal* can be taken up on the large scale by *zamindars*, some method of disposing of the crop to advantage must be found. The green crop is a safe fodder for horses and cattle and particularly for dairy cows, provided care is taken to mix it with sufficient *bhusa*. Lucerne, however, is undoubtedly a more popular green fodder and is now grown on a large scale round Quetta. Green forage, however, can only be produced in the summer and during the winter there is a large demand for dried fodder. This is at present met by lucerne, dried in the country fashion, without fermentation. The harsh and brittle nature of this food is obvious and it has the further disadvantage that it cannot be made into pressed bales. During 1914, experiments were made in the drying and baling of *shaftal*. By carefully adjusting the moisture it was found possible to make *shaftal* into good hay, to obtain the proper fermentation in the stack and to press it into bales. This can only be done in the exceedingly dry climate of Quetta by conducting the operation in all its stages in such a manner that the *shaftal* never becomes air dry. Once it is completely dried out, it is so brittle that it cannot be handled and baling is out of the question. The final product was indistinguishable from good English clover hay. Over a hundred bales were prepared in 1914 and tried as a fodder by one of the Heavy Batteries at Quetta during the winter. The Commandant reported that it was an excellent fodder, much superior to

dried lucerne. A much larger number of bales has been prepared during the present year which will be offered to various units of the Quetta Division for trial next winter. The military advantage of a pressed fodder, equal to English clover hay, is obvious in India while the extended cultivation of *shaftal* in the Quetta valley would be certain to increase production and thus augment the present supplies.

Lucerne. The methods of growing lucerne in Baluchistan are of some interest. The land is first of all manured before sowing and every year the crop is top dressed with more manure during the winter. There is no cultivation at any stage and water is applied by flooding the surface. The frequent manuring evidently promotes aeration of the surface soil and so removes some of the disadvantages attending the method of watering. Evidence has been obtained that surface cultivation of the lucerne after irrigation by means of the spring tine cultivator is likely to take the place of the manurial dressings. An experiment has been started to compare the yield of green crop under the two methods of treatment.

Some trials were made in 1914 to prepare and bale real lucerne hay in place of the dried unfermented local product. While it is possible to make good lucerne hay in the dry atmosphere at Quetta, the process is not easy on account of the fact that the moisture is so readily lost before fermentation takes place. *Shaftal* is much more easily made into hay at Quetta than lucerne.

Other fodder crops. Besides *shaftal*, several other new fodder crops have been tried. Ordinary English red clover grows at Quetta and withstands the hot weather of July but the rate of growth is not great and this fodder is not likely to compete with *shaftal* and lucerne. Italian rye grass behaves much like red clover but the difficulties connected with the germination of the seed under local conditions are likely to prevent this crop ever being taken up. A mixture of rye grass and *shaftal* was found to be unsuitable for hay as the rye grass dries much too quickly. Ber-

seem (*Trifolium alexandrinum*), which does so well in Sind, will grow at Quetta but the weight of crop is small and it is not likely to be of use in the valley. A Mediterranean fodder crop known as sulla (*Hedysarum coronarium*) was tried in 1914 at the suggestion of Mr. A. C. Dobbs, Assistant to the Agricultural Adviser to the Government of India, but it proved a complete failure and was largely killed by the cold.

Fruit Investigations. *Improved fruit boxes.* The supply of improved fruit boxes for the use of dealers and the public was continued during the year. The demand is steadily increasing both on the part of the Indian dealers and also from the general public. About 2,500 boxes were sold during the year and as these are distributed all over India they ought in time to help to raise the present low standard of fruit packing in the country.

Some improvements have been made in the design of the packages for the five seer parcel rate. The use of chip compartments is being given up while the boxes are being made more thief-proof. In place of the separate chip compartments, a collapsible cardboard fitting has been used. This folds flat and is imported ready for use. Peach boxes entirely of cardboard were put on the market for the first time in 1914. The whole of the outside of the box consists of a single piece of cardboard and the boxes can be set up very rapidly. The separate compartments are of collapsible cardboard. With these boxes, thefts in transit are quite impossible. The supply was sold off at once and, judging by the demand, cardboard fruit boxes are likely to become exceedingly popular in India. They can be used several times over if necessary.

For consignments over five seers in weight, fruit packing cases must be made of wood and, to travel well for long distances under Indian conditions, it is essential that there should be a system of small units like the two pound punnets which are now being adopted at Quetta. There is one difficulty, however, which must be overcome, namely,

a reliable source of box boards at a reasonable price. Originally, these box boards were imported from Glasgow but the rise of wages and freights has increased the cost considerably. At the present time, the conditions of trade with Great Britain have still further increased prices. A large amount of time has been spent in trying to discover an indigenous source of suitable wood but without much success. India apparently has not yet reached the stage when cheap boxes are required in numbers. Most of the trade is still in the gunny bag and wicker basket stage. It is possible that after the war, the necessary boards for fruit packing boxes can be best obtained direct from Norway.

Supply of fruit trees. A beginning was made in 1913 in the supply of fruit trees to the public. Only good varieties which suit local conditions are propagated and care is taken to shape the trees in the nursery during the summer before they are distributed. The demand for this stock has rapidly increased and during the past year between four and five thousand trees were sold. No trees are given away and proper prices are charged. This tends to check waste and also ensures that most of the trees distributed are properly cared for afterwards.

Experience shows that the further development of fruit growing in Baluchistan is to a great extent a question of suitable varieties propagated on suitable stocks. A large collection of the best local and imported kinds is being made and added to every year. The experiments on the influence of the different stocks are already yielding most interesting results. The mahaleb, mariana, mirabolan and almond are likely to prove exceedingly useful as stocks in the Quetta valley. For the present, the first three have to be imported from France. With proper care, however, the percentage of deaths is very small and it might easily prove cheaper to import stocks in bulk than to raise a local supply. As the new varieties come into bearing and as the various experiments with stocks develop, it will be possible to improve the nursery work still further. Before the Experiment Station was started, no records of varieties had

been kept at Quetta so that all this work has had to be done over again from the very beginning.

IV. Programme and Publications.

Programme of work for 1915-16. *Plant breeding and plant improvement.* Work will be continued on the following crops, on the lines indicated in the annual reports and in the publications of the section—wheat, tobacco, gram, fibre plants, indigo, oil-seeds and fruit.

Publications. Some progress was made during the last twelve months in the publication of results but the arrears have not yet been overtaken.

The following papers were published during the year :—

1. The influence of the environment on the milling and baking qualities of wheat in India. No. 3. The experiments of 1911-12 (with H. M. Leake). *Mem. Dept. of Agr. in India (Botanical Series)*, Vol. VI, No. 8, 1914.
2. Pusa 12. *Agr. Jour. of India*, Vol. X, Part 1, 1915.
3. The improvement of tobacco cultivation in Bihar. *Bulletin 50, Agricultural Research Institute, Pusa*, 1915.
4. First report on the improvement of indigo in Bihar. *Bulletin 51, Agricultural Research Institute, Pusa*, 1915.
5. Soil Ventilation. *Bulletin 52, Agricultural Research Institute, Pusa*, 1915.
6. Soil Erosion and surface drainage. *Bulletin 53, Agricultural Research Institute, Pusa*, 1915.
7. Second report on the improvement of indigo in Bihar. *Agr. Jour. of India*, Vol. X, Part 2, 1915. Reprinted as *Bulletin 54, Agricultural Research Institute, Pusa*, 1915.
8. Report on Agricultural Botany for 1913-14, for the Board of Scientific Advice.

REPORT OF THE IMPERIAL MYCOLOGIST.

(F. J. F. SHAW, B.SC.)

I. CHARGE AND ESTABLISHMENT.

The Officiating Imperial Mycologist remained in charge of the section throughout the year. There were no changes in the establishment. The Officiating Imperial Mycologist was on tour for 77 days during the year and the First Assistant for 75 days; the "ufra" disease in Eastern Bengal, the wilt of chillies at Peshawar and the recent outbreak of "black thread" on rubber plantations in Burma absorbed most of this time. The number of mycological investigations in progress at some distance from Pusa, for Provincial Departments of Agriculture and Forest and Opium Departments, is increasing every year. All the staff have worked well.

II. TRAINING.

Babu Jamini Bhusan Sinha, Fieldman in Mycology, Sabour, was under training from December 5th, 1914. Mr. S. L. Ajrekar, B.A., Assistant Professor of Mycology, Poona College, worked in the laboratory from 28th October to 5th November 1914. Mr. B. L. Gupta, B.Sc., of the Reid Christian College, Lucknow, completed a course in Mycology, which he commenced on 11th May 1914, and left Pusa on 8th July 1914.

III. DISEASES OF PLANTS.

The investigation of the diseases of crops, the collection and identification of Indian fungi and giving assistance to cultivators and officers of the Department formed the principal work of the section.

(1) **Paddy.** The work on "ufra," the nature of which was described in the last annual report, was continued and experiments were conducted at Comilla and at Pusa with a view to the discovery of some remedial measure. Owing to a deficiency of water in the experimental area at Comilla

this work did not give any conclusive results. The experiment is being repeated this year with additional precautions.

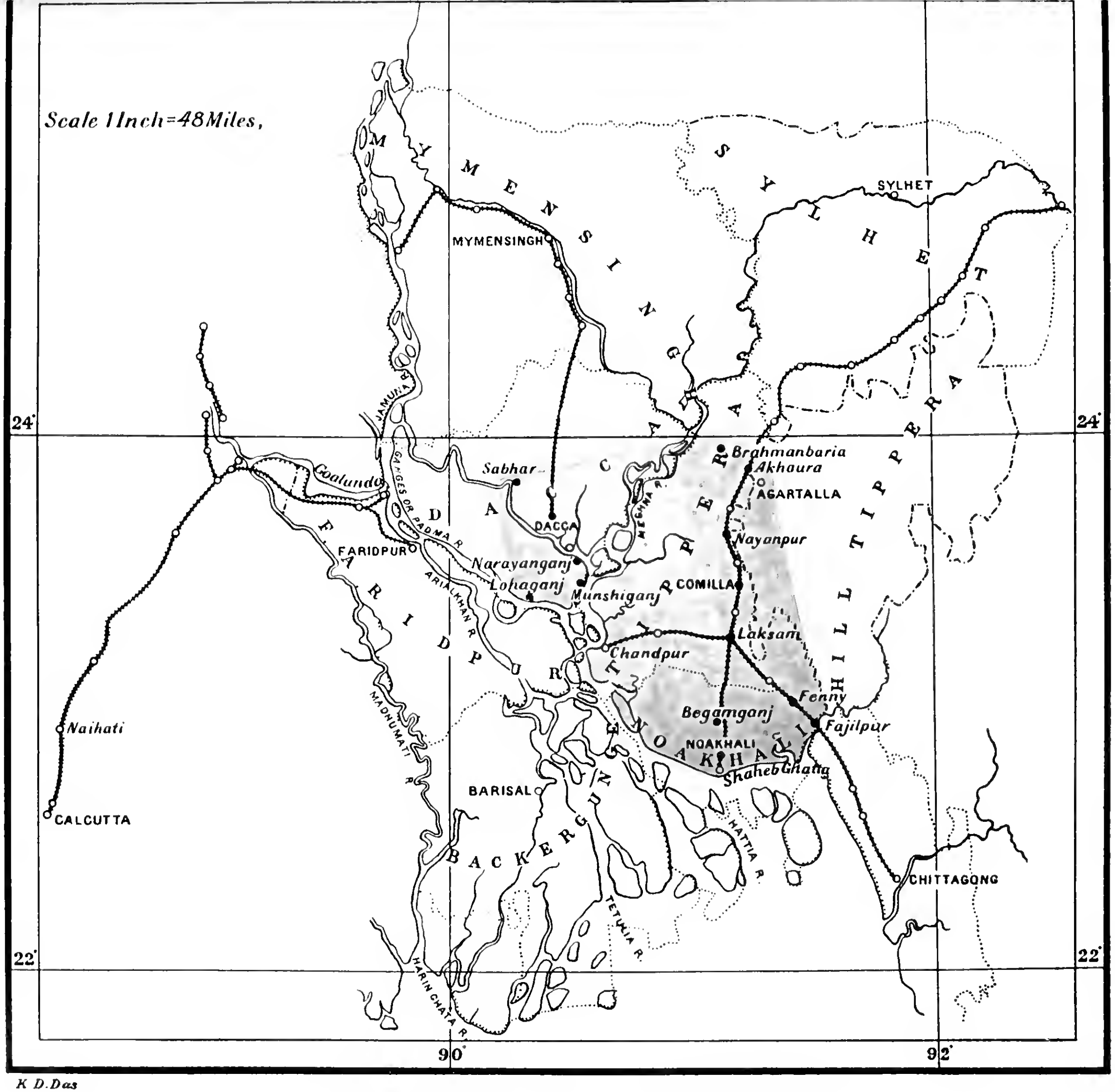
Working with small plots at Pusa it was found that the disease could lie dormant in the soil and infect a new crop. Cutting the diseased crop and burning it *in situ*, with a little kerosine, prevented the infection of a succeeding crop. It is unsafe, however, to generalise from a small experiment such as this, for it is possible to subject a small area to a much more thorough burning than would be practicable on a field scale.

The infected area in Eastern Bengal appears to be much the same as last year (see map) and the disease has been again reported in the vicinity of Ranchi, in Bihar and Orissa, where it is said to occur on transplanted paddy and not upon the early broadcast.

A diseased condition of the paddy crop in Balasore and on the Government Farm at Bankipore was investigated but "ufra" was not found; at Balasore drought appeared to be the cause of the trouble but at Bankipore the condition was said by local officers to be that known as "chatra," however, no trace of a parasite could be found.

The "gwa-bo" disease, which is the cause of extensive damage in Burma, was investigated without any very definite result. In some areas about 50 per cent. of the disease appears to be due to *Sclerotium Oryzæ* Catt. (vide *Memoirs of the Department of Agriculture in India, Botanical Series*, Vol. VI, No. 2, July, 1913) but it is almost certain that the diseased condition is the result of the combination of a number of adverse factors and is not due to the attack of any single parasite. In particular some insects appear to be responsible for a large amount of the disease.

(2) Tobacco. Field experiments with "tokra" of tobacco were commenced and yielded some results of scientific interest. *Orobanche cernua* Loefl. and *Orobanche indica* Buch. both occur on tobacco but *O. cernua* is much the more serious parasite of tobacco and solanaceous crops generally, while *O. indica* is a source of heavy damage to



MAP SHOWING DISTRIBUTION OF *UFRA*.

ENGRAVED & PRINTED BY THE CALCUTTA PHOTOTYPE CO

Cruciferæ (*e.g.*, mustard, cabbage). A good crop of tobacco was raised on a field which had been under cabbages in the previous season and which was known to be infected with *O. indica.* Further experiments to test the effect of different chemical manures on the incidence of "tokra" are in progress.

(3) Rubber (Hevea). At the request of the Director of Agriculture, Burma, the section undertook the investigation of a disease of *Hevea* called "black thread" in Lower Burma. The disease is characterized by the appearance of longitudinal black lines in the naked tissue immediately above the tapping cut. These black lines mark areas of disintegration, stretching through the cambium into the wood, and as tapping proceeds they follow the fresh cut down the stem. The flow of latex becomes decreased, but, the most serious aspect of the disease is the failure of an infected tree to regenerate the bark over the tapped area.

Microscopic examination of the black cracks has, up to the present, failed to demonstrate the presence of any fungus parasite, but in the bark immediately adjoining the infected area hyphæ of a fungus often occurred. This fungus was identified as *Phytophthora* the cause of the "canker" of Hevea. At the moment of writing the investigation has not been carried further but experiments are in progress.[1]

(4) Sal tree (Shorea robusta). At the request of the Bengal Forest Department the section undertook the investigation of a disease in the sál forests of the Duars, said to be due to a fungus parasite. In the Buxa Division a considerable number of sál trees can be seen in a dead and dying condition. When dead the trees are left standing bare and leafless and in dying trees the foliage is scanty and there are obvious indications of a decrease in vigour of growth. In all the dead and dying trees which were examined there were indications of a fungus attack in the roots. If the main root of an unhealthy tree is laid bare

[1] Infections with pure cultures of this *Phytophthora* have since been successful in producing this disease on healthy trees.

to a depth of about 3 feet and the outer corky tissues are cut away with a knife it is found that the phloem has been destroyed leaving nothing but the bast fibres; in the disintegrated tissue between the strands of fibres white rhizomorphs occur and a fungus mycelium is everywhere common. In dead and badly affected trees this condition is found to extend up the trunk sometimes as much as 2 feet above the soil. In such cases a fructification of a bracket fungus (probably *Fomes*) is often found on the stem. In every case examined in which this fructification was present the phloem showed the diseased condition described above. Thus while all unhealthy trees show a diseased condition of the phloem, with the presence of a mycelium with rhizomorphs, the most advanced cases of disease also bear a sporophore. From field observations therefore there is a strong presumption that the disease is due to the attack of a basidiomycete of the genus *Fomes;* the fact that this fungus is one of a group which is responsible for most diseases of timber strengthens the evidence and moreover the presence of rhizomorphs in the diseased phloem is what would be expected in association with a *Fomes* fructification on the exterior of the trunk.

The fungus has been obtained in pure culture and will be tested by inoculations. While it is not unlikely that the fungus is the direct source of damage it will probably be found that the conditions under which the sál trees are living are such as favour the presence of a fungal parasite and decrease the vitality of the sál tree. When the factors which are necessary for the fungus to gain entrance into a healthy sál tree are known it may be possible to control the disease by altering the hygienic conditions under which the trees live and thus lessening the chances of a successful infection. It is improbable that it will be possible to apply any remedial measures in dense jungle such as occurs in Buxa; treatment might, however, be possible in the case of plantations.

(5) Rhizoctonia. Work on this fungus was continued and the results are published as a memoir of the Depart-

ment. The species *R. Napi* West. was found to be a dangerous parasite of mustard and gram. This fungus is incapable of active growth at temperatures above 29°C.—a circumstance which limits its depredations in India. A fertile stage was discovered and found to be identical with the well known *Botrytis cinerea* Pers., which was described as a disease of mustard by Frank some forty years ago. As a result of this it is considered that *R. Napi* is not a true member of the genus *Rhizoctonia*, which should be restricted to those species with a fertile stage in the genera *Corticium or Hypochnus*. The species *R. destruens* Tass. was found to be the cause of serious disease of betel vine and potato in Lower Bengal, Bihar and parts of Bombay. In the latter province it also occurred on suran, lucerne and groundnut. There were some indications that the fungus had a perfect stage in the genera *Corticium* or *Hypochnus* but no satisfactory proof could be obtained. Experiments suggested that corrosive sublimate was a more reliable fungicide against *Rhizoctonia* than formalin or copper sulphate.

In continuation of the research into the blight of opium poppy experiments were conducted with a view to discovering whether *Rhizoctonia* or *Peronospora* was the chief cause of this disease. Poppy was grown at Pusa from seed supplied by the Opium Department and the resulting crop became infected with *P. arborescens*. This fungus was also very plentiful on poppy in the vicinity of Ghazipur, but at Patiali *Rhizoctonia*, and not *Peronospora*, was found. The matter cannot be regarded as definitely settled but it is probable that *Rhizoctonia* is only a serious parasite of poppy when conditions such as poor soil or defective drainage are inimical to the growth of the crop.

(6) Anthracnose. The investigation into anthracnose of betel vine did not yield any results of practical importance. There is no doubt, however, that the perfect stage of this *Colletotrichum* is an ascomycete belonging to the genus *Glomerella*. Attempts to secure successful inoculations failed and our knowledge of this disease is therefore not

in so good a position as it appeared to be last year. The well known anthracnose of chillies appears to be the cause of a good deal of trouble in the chilli growing districts of Burma and some form of treatment may be necessary.

IV. Miscellaneous.

A certain amount of work was done on the fungi of Pusa soil. The chief interest of this preliminary investigation was the striking similarity between the fungus flora of an Indian soil and that which occurs in Europe. The species isolated in Pusa were—

Cunninghamella elegans Lendn.
Aspergillus fumigatus Fres.
Aspergillus niger v. Tiegh. *Sterigmatocystis nigra* v. Tiegh.
Rhizoctonia Napi West.

of which the first three are all known in the soil in Europe.

The fungus which causes " red rot " of sugarcane was found to be parasitic upon juar under laboratory conditions but so far is not known to cause serious damage to this crop in the field. A rot of bananas was examined by the First Assistant and found to be due to a parasitic *Fusarium*. A preliminary account has been published in the *Agricultural Journal of India*, it appears that the disease is distinct from the well known Panama disease of bananas. The results of some observations on potato blight in India have been published as a memoir of the Department, the chief point of practical importance is the fact that the fungus cannot survive in the heat of the plains. Mr. Dastur has continued his work on *Phytophthora* with the study of some forms parasitic on *Vinca*, it is hoped to publish results shortly.

Some preliminary work on the disease of chillies at Peshawar indicated that the disease was of the type known as "wilt." Inoculations with a fungus isolated from diseased plants were not successful and this year the incidence of the disease is much less. Treatment of oat smut

with formalin on certain estates in Bihar was, as usual, completely successful.

V. Systematic Work.

The additions to the herbarium amounted to 155 specimens during the year. Collections of fungi for naming were received from, and duplicates were issued, if required, to the Mycological Officers of Provincial Departments. The publication of systematic mycology by the Imperial Mycologist has been largely done in collaboration with Herrn H. and P. Sydow of Berlin; the outbreak of war with Germany has of course prevented this collaboration being continued and will hinder the publication of the series "Fungi Indiae Orientalis."

VI. Programme of work for 1915-16.

(1) *Research work.* All new fungus diseases of crops will be the subject of investigation as they come to the notice of the section but the following diseases will receive special attention and will constitute main lines of investigation :—

(1) Ufra of paddy.
(2) Smut of sugarcane.
(3) Wilt of cotton, sesamum, gram and chilli.
(4) Black thread disease of rubber.
(5) Blight of opium poppy.
(6) Root rot of sál tree.

Research work will also be continued upon phanerogamic parasites and fungi of the soil.

(2) *Systematic work.* The care of the herbarium will continue to form an important part of the work. Minor papers on systematic mycology will probably be published.

(3) *Training.* This will be continued on the lines indicated in the prospectus. Short courses may be given as necessary.

(4) Routine work of advising on plant diseases will be continued and assistance will be given as usual to Provin-

cial Departments of Agriculture, the Forest Department, Planters' Association and general public.

VII. Publications.

(1) Butler, E. J. . The cultivation of Rice in Spain and the Recent International Rice Congress at Valencia. *Agri., Jour., India, IX, Pt.* 4, Oct. 1914.

(2) Dastur, J. F. . The Potato Blight in India. *Mem. Dept. of Agri., India, Bot. Ser.* VII, No. 3, April, 1915.

(3) Shaw, F. J. F. . Report on Mycology, 1913-14, for the Board of Scientific Advice.

REPORT OF THE IMPERIAL ENTOMOLOGIST

(T. Bainbrigge Fletcher, F.E.S., F.Z.S.)

I. Charge and Establishment.

The Imperial Entomologist held charge of the section throughout the year. Mr. A. J. Grove, Supernumerary Entomologist, whose services had been lent to the Punjab Department of Agriculture since 27th January 1914 for the investigation of insect damage to stored wheat, left the Department on 27th April 1915 on termination of a six months' extension of his probationary period. Mr. G. R. Dutt was on privilege leave from 5th October to 4th November 1914 and Mr. D. Nowroji from 5th to 31st October 1914. The services of G. D. Ojha, Fieldman, were lent to the Department of Agriculture, Central Provinces, for six months from 5th April 1915 in connection with work on *Nephotettix*.

II. Tours.

The Imperial Entomologist was on tour in Burma from 26th July to 6th October, in the Punjab and North-West Frontier Province from 9th to 25th October, in the Central Provinces from 9th to 18th April, in the North-West Frontier Province from 13th May to 1st June and also visited Calcutta to work at the Indian Museum from 14th to 23rd June, a total absence from headquarters of 130 days.

Mr. C. S. Misra, First Assistant, visited the Central Provinces in July 1914 to investigate cane-borers and again in February 1915 to inquire into an outbreak of *Nephotettix* in rice areas for which purpose he also toured in the Central Provinces and Orissa from 5th to 21st June 1915. He also visited the Karauli and Benares States in February and May respectively to advise regarding development of the lac industry.

Mr. C. C. Ghosh visited the Sepaya Farm in September 1914 to examine the indigo planted in connection with *Psylla* experiments.

Mr. G. R. Dutt toured in Southern India from 29th March to 17th May 1915 to collect information and specimens of insects, especially Hymenoptera.

Mr. M. N. De, Sericultural Assistant, visited Muktesar in October 1914 to distribute directly from there the univoltine mulberry silkworm eggs which had been placed in cold storage during the hot weather. He also went to Calcutta in November 1914 to assist in displaying the silk exhibits sent from Pusa for the Exhibition of Indigenous Products as compared with Enemy Goods.

The Fieldmen were sent on tour as occasion required throughout the year in connection with outbreaks of pests.

III. Training.

No students completed the course in Entomology during the year but two were received from the Punjab in June 1915. G. D. Ojha and Harihar Prasad, Entomological Fieldmen at Pusa, were also given some special training. The short courses in Lac and Sericulture only attracted four students, a number much below the average; the Banswara State, Central India, sent one man for the Lac course in June 1915, one student completed a course in Eri and Mulberry Silk and two Sericultural students remained under training at the close of the year. The reduction in numbers of the short-course students seems to be directly due to the publication of popular Bulletins on the culture of lac and silk, although it may be noted that mere book-instruction cannot take the place of practical work.

IV. Crop Pest and other investigations.

1. Cotton Pests. Experiments, which are still in progress, were made to test the relative immunity of different varieties of cotton to attacks of bollworm (*Earias*). A large number of sowings were made of numerous cottons from the United Provinces, the Punjab, the Central Provinces and

Bombay in combination with other malvaceous plants, and weekly counts made of the bollworm infestation. The bollworms found were also examined for the presence of parasites, which were recorded, bred out and liberated in the experimental area. So far as noted hitherto the infestation of *Earias* by *Rhogas* is remarkably small (less than 5 per cent.) even under the most favourable conditions, and it would appear that the influence of *Rhogas* has been greatly exaggerated. In May and June 1915, in compliance with a request from the Director of Agriculture, all the *Rhogas* pupæ obtained were sent to the Punjab to assist in establishing the parasite there.

Some work has also been done on the life-history of *Machærota planitiæ*, whose nymph lives in a curious calcareous tube on stems of cotton. The presence of this insect frequently stunts the growth of the young shoots and it may occur in sufficient numbers to do considerable damage.

2. Sugarcane Borers. Borers in sugarcane (both new sowings and ratoon canes), maize, *juar*, and rice stems and stubble have been collected and the insects bred out for further study and comparison. Affected canes were also received from the North-West Frontier Province and the insects reared. In March 1915 fresh sowings of cane were made with maize as a trap-crop and, as soon as the presence of borers became apparent, these were collected, counted and reared for further study to ascertain whether the borers in cane and maize are really distinct; this experiment was not concluded at the end of the year.

3. Garden Pests. The study of pests of fruit-trees, flowers and vegetables was continued and illustrations made for a Bulletin on Fruit-pests.

4. Parasites of Scale-insects. With a view to sending parasites of *Aspidiotus aurantii* to Italy, a study was begun of the parasites of this scale-insect which occurs commonly at Pusa on *Citrus* spp. and roses, but very few parasites could be obtained.

A large amount of Lecaniinæ material was collected with a view to finding any parasites which might be of use in the control of *Coccus viridis* (*Lecanium viride*) in the coffee districts of Southern India, but it was found that the majority of the local *Lecaniinæ* were free from Chalcid parasites; only those scales found on *Ficus religiosa* and *Ricinus communis* were parasitized to any extent.

5. Parasites of Aleurodids. As noted in last year's report, attempts have been made to procure a parasitized colony of *Aleurodes citri* for export to Florida. The parasite which attacks *A. citri* on *Jasminum* is the same as the one which attacks *A. ricini* on castor, and castor plants were therefore grown and infected but unfortunately became heavily infested with *Tetranychus bimaculatus* and later on by a leaf-fungus and the plants therefore had to be rejected. A very similar parasite attacks another *Aleurodes* on *Ficus* and trials with this are also being made.

6. Economic Aleurodidæ. Life-histories of *Aleurodes citri*, *A. bergi*, and *A. ricini* were completed.

7. Pyrilla aberrans. The complete life-history of *Pyrilla aberrans* was worked out during the year and repeated thrice to check the period of a life-cycle. Chalcid, Dryinid and Stylopid parasites were also reared, some of these being new. It may be noted that three species of *Pyrilla* (*P. aberrans*, *P. perpusilla* and *P. pusana*) are found on sugarcane at Pusa, all formerly confused under the first name.

8. Nephotettix bipunctatus. Much time was given to the outbreak of *Nephotettix bipunctatus*, the rice leaf-hopper (locally called "Maho") in the Central Provinces. This insect was first reported as a pest from the Sakti State in the Bilaspur District of the Central Provinces. A Fieldman was sent to make investigations on the pest and to try measures suggested from Pusa. These measures consisted of (1) bagging with large field bag-nets, (2) bagging with hand-nets, (3) brushing over the infested fields with a rope dragged over the plants, (4) oiling the infested fields with kerosine and then dragging a rope across so as to

submerge the plants temporarily, (5) spraying with contact insecticides, and (6) putting up lantern traps in the affected fields. Of these, it was found that the last was the most efficacious and that most readily adopted by the cultivators.

A leaflet on this pest in English and Hindi was written and issued by the Department of Agriculture, Central Provinces, and widely circulated amongst the cultivators of the affected districts. It has also been translated into Uriya and issued by the District Board in Balasore, where an outbreak of *Nephotettix* also occurred. A trained Fieldman was lent to the Central Provinces to carry on continuous observations of the pest and to advise adoption of remedial measures in the Raipur and Bilaspur districts which were severely infested last year.

9. Life-histories. In the insectary were reared some two hundred insects which had not been reared previously. Considerable attention has been paid to various insects (mostly Coleoptera) found at and just below soil-level and about sixty different beetles have been reared and their breeding-places, earlier stages, food and habits noted. Many of these beetles are predaceous and are therefore beneficial by destroying plant-feeding crop-pests; amongst such may be noted an unidentified Carabid predaceous on a Cydnid bug, a species of *Chlœnius* predaceous both in the larval and adult stage on caterpillars of *Utetheisa pulchella*, and several Elaterid beetles. Of these last a single grub of *Agrypnus* sp. ate more than 200 Scaraboeid grubs in the course of about three months, and another Elaterid larva was found to exercise a considerable check on Tenebrionid grubs feeding at the roots of gram and other crops.

A point, which has been observed with regard to some common insects (*Laspeyresia*, *Chilo*, *Chloridea*) reared for observation of exact cycles of their life-history, is that out of the same batch of larvæ, feeding and commencing to hibernate at the same time, some hibernate and emerge as adults whilst others hibernate during the cold weather,

then æstivate during the hot, dry season and emerge at irregular intervals thereafter as late as July or August. From the practical point of view of control this is of some importance, as measures taken on the first appearance of the insects after hibernation may be rendered abortive, or will at least require to be supplemented, in view of these later emergences. An observation of this kind, apparently trivial in itself, emphasizes the fact that an intimate knowledge of the habits of the insects concerned must be the first step towards their control.

Crocidolomia binotalis is a cold weather pest of Cruciferæ. Unsuccessful attempts were made to find out how it passes through the rest of the year.

Zonabris pustulata is an extremely common black and red Blister beetle whose life-history is yet unknown. Eggs were obtained in November 1914 and hibernated in the soil, hatching at the end of the cold weather, but all attempts to get the young larvæ to feed on eggmasses of various grasshoppers proved unsuccessful, and the grubs could not be reared. Dr. Roepke, of the Experimental Station at Salatiga in Java, has recently informed me that he found larvæ of this species feeding on eggmasses of *Cyrtacanthacris*; it is probable that this beetle has a similar habit in India.

Another failure was encountered in further attempts to obtain the life-history of *Anthia sexguttata*, a giant Carabid which feeds in the adult state on practically any insects it is able to catch.

A Bruchid beetle (*Bruchus affinis*) was observed to lay eggs extensively on pea-pods at Pusa in January and February, so that the peas may be infected in the field before being stored. These seeds have been treated and stored in various ways to ascertain the extent of damage and how it can best be checked.

An unidentified Dermestid beetle in stored wheat has been found to complete its transformation in from one to two years.

Further observations have been made on the life-history of *Odoiporus longicollis*, a weevil which bores in plantain stems, and the life of the adult beetles has been found to extend to a period of up to two years.

With reference to the campaign against *Agrotis ypsilon* at Mokameh it was not known how this insect passes through the hot weather and rainy season in the plains of India. Large numbers were therefore obtained in March and it has been found that, under conditions in the Insectary, continuous broods have been obtained, which suggests that it may breed somewhere in the vicinity of the areas attacked in September-December.

The status of *Tenebroides mauritanicus* as a grain-pest having been doubtful, this was ascertained by experiments, by which it was found that this beetle and its larvæ certainly can and do eat wheat and rice grains, preferring wheat to rice. The adult beetle preys upon the adult rice weevil, *Calandra oryzæ*, so that in grain affected by *C. oryzæ* the presence of these beetles is beneficial as, when present in sufficiently large numbers they will ultimately rid the grain of the weevils although they themselves will eat a small proportion of the grains; but the resultant loss will be less than if the weevils bred unchecked. Further experiments will be undertaken with this insect.

Batocera rubus, a longicorn beetle commonly boring in Fig, Mango, etc., has been reared from the egg and the complete life-cycle observed to occupy a year.

Balaninus c-album has been traced throughout the year, though not reared from eggs. The life-cycle occupies a year.

Complete life-cycles have been observed of *Plotheia celtis*, *Porthesia xanthorrhœa*, *Perigea capensis*, *Spodoptera mauritia*, *Liogryllus bimaculatus*, *Terias hecabe*, *Hypolimnas bolina*, *Euplœa core*, *Junonia orithiya*, *Huphina nerissa*, *Papilio polytes* and *Deilephila nerii* and further observations have been made on numerous other insects.

Fruit-flies have been reared in large numbers—in thousands in some cases—from various fruits in order to procure parasites and to ascertain the proportion parasitized. In the case of *Bactrocera cucurbitæ* the results have been disappointing as parasites were very few and it is perhaps owing to this fact that this fruit-fly does so much damage to cucurbitaceous vegetables. Only in one lot of fruits of *Momordica charantia* were the maggots found to be attacked by a Braconid parasite to the extent of about 16 per cent., and even this parasite was not found to be present throughout the year. The peach-flies (*Bactrocera zonata*) showed an insignificant percentage of parasitism and the parasitic grubs were observed to remain in a resting condition throughout the remainder of the year.

Carpomyia vesuviana was reared from fruits of Ber (*Zizyphus jujuba*) and was found to be extensively parasitized. Attempts will be made, at the request of the Royal School of Agriculture at Portici, to introduce this parasite into Italy, whence this fruit-fly was originally described its specific name being derived from the fact that the original specimens were taken on the slopes of Mount Vesuvius. The flies remain in the pupal state for some time, from about February to June or later, but the parasites emerge about March and probably have an alternative host.

In order to test the effect of poisoned sprays on fruit-flies long series of flies reared in the insectary were fed with a solution composed of Lead Arsenate $2\frac{1}{2}$ to 5 oz., *gur* $2\frac{1}{2}$ lb. and water 4 gallons, and it was found that a strength of 3 to 5 oz. of Lead Arsenate kills the flies in about 36 hours.

A Braconid parasite of *Diacrisia obliqua* was bred for a generation to note its life-cycle and rate of increase and some work was also done on an Ichneumonid parasite of *Spodoptera mauritia*.

Odontotermes assmuthi, the largest of the five Termites known to occur at Pusa, has been under observation for the last four years. From the emergence of adults which

took place in July 1914 several observation nests were established in the Insectary and new colonies were successfully started and soldiers and workers reared. This is the first time, so far as I am aware, that any species of the true earth-dwelling *Termitidæ* has been reared from the egg to any adult stage under observation, although some of the woodliving *Protermitidæ* and *Mesotermitidæ* have been reared in Europe. Further colonies are now being reared.

10. Insecticides. Experiments in the preservation of wood against attacks of Termites (White Ants, so called) were continued, the species of Termite experimented with being *Microtermes obesi* (*anandi*), which is apparently a common species throughout the plains of India. " Powellized " wood, supplied by the agents for testing, has failed almost wholly within four years. " Sideroleum," tested as a preservative of wood against Termites, has also failed; further tests will be made of it. Testing of " Microlineum " as a preservative has been started.

Creosote was tried to make sugarcane setts immune to Termites without interfering with germination, but these experiments failed.

11. Stored grain pests. A series experiments on the preservation of rice, wheat and pulses against insects under stored conditions has been commenced on a small scale. The methods found most effective will be tested on a larger scale.

12. Silk. One student completed a short course in Eri and Mulberry and two were undergoing training at the close of the year. The univoltine mulberry silkworm eggs, which were sent to Shillong and Muktesar for rearing in March, gave satisfactory results but those sent to Muktesar for rearing in October did not hatch properly as the natural temperature of the place from July to October was not sufficiently low. Our attempts to establish a superior stable multivoltine hybrid race, which would not degenerate, were continued. Mulberry silkworm eggs were supplied to 171 rearers and eri eggs to 144 applicants and

mulberry and castor seeds to 20 applicants. One Fieldman and a rearer were sent to Jeolikote, Kumaon, for rearing eri worms in April and May as it is difficult to procure a fresh stock of eggs for distribution in June and July. Thirty-one pounds of eri cocoons were supplied to Messrs. Inagaki & Co. of Kyoto for testing in the mills of Japan. Difficulty was experienced by the rearers in disposing of eri cocoons in small lots. Silk exhibits were sent to Exhibitions held at Muzafferpur, Monghyr, Pudukottai, Mysore and to Calcutta, Madras and Cawnpur in connection with the Exhibition of Indian as contrasted with German and Austrian goods. The Secretary of the Mysore Dasara Exhibition awarded a silver medal for the exhibits. Eighteen silk pieces were loaned to the Director General of Commercial Intelligence, Calcutta, for the Exhibition of Indian as contrasted with Enemy Goods. Eight sets of silk exhibits were sent to the Superintendent, Central Seed-store, Bengal, Sibpur. His Highness the Maharaja of Darbhanga took a keen interest in all the operations of the industry during His Highness' visit to the Institute. Instruction was given by correspondence in silk-dyeing, bleaching, silkworm rearing, reeling and spinning. Rupees 937 worth of silk, manufactured at Pusa, was sold.

13. Lac. During the past year emergences of larvæ took place on the 28th September 1914 and 10th June 1915 and in the two seasons 120 Ber trees were inoculated. Broodlac was supplied to 7 persons. Specimens of lac from two new food-plants, which were not hitherto recorded, were received from the Honorary Secretary, Agri-Horticultural Society of India, Calcutta, and the Economic Botanist, Lal Bagh, Bangalore. Parcels for sending in lac specimens were sent only to such Forest Officers from whose Division or Range the series of specimens was not complete. Unfortunately serious gaps occurred in the past and these have not been filled up as yet.

Five tubs containing Kusumb (*Schleichera trijuga*) plants were inoculated and despatched to Mr. N. Fujii,

Hozan, Formosa, through the Consul-General for Japan, Calcutta.

During the year the services of Mr. C. S. Misra, First Assistant, were requisitioned by the Karauli Durbar to report on the progress of lac cultivation started by the Forest Officer of the Durbar who was trained in Lac work at Pusa. A separate report embodying his suggestions was submitted to the Durbar through the Political Agent Bharatpore.

In May 1915 Mr. Mistra's services were requisitioned by the Benares State to advise on the possibility of extension of Lac cultivation in the Chakia district of the State. A separate report on this embodying his suggestions has been sent to His Highness the Maharajah of Benares through the Political Agent to His Honour the Lieutenant-Governor of the United Provinces, Benares.

A student was deputed by the Banswara State in Central India to undergo a month's training in Lac culture. The student joined the course on 7th June 1915 and went back to the State on the 3rd July 1915.

Copies of the Lac Bulletin in English and Hindi were sent or sold to numerous inquirers.

14. Bees. During the year experiments with the Indian Bee (*Apis indica*) were continued, special attention being paid to the three principal defects of this bee in the plains, *viz.*, (1) deserting the hive in autumn, (2) inability to defend the hive against Wax Moth, this being one of the causes which lead to desertion, and (3) frequent swarming.

The results obtained this year go to show that the bees can be prevented from deserting the hive and a little care prevents the Wax Moth, a well-made hive being of great help in this direction. A little care bestowed on these bees leads to an increase of the population in the colony but stimulates swarming. Efforts made at checking swarming were not successful. It appears that the old principle of inducing swarming early in the season so as to have a number of colonies from which to take surplus honey in the honey season, will be more suitable to these bees than the

new principle of checking swarming and having larger surpluses from strong and populous colonies. The work will be continued. A Bulletin on Bee-keeping was issued at the close of the year.

V. Illustrations.

Illustrations were prepared, to the extent of artistic assistance available, of the insects studied during the year. Coloured plates, showing the complete life-history, were prepared during the year of the following insects:—*Utetheisa pulchella*,* *Odoiporus longicollis*,* *Atractomorpha crenulata*, *Oxycarenus lætus*, *Plusia orichalcea*, *Perigea capensis*, *Etiella zinckenecella*, *Glyphodes indica* and *Chilo simplex*,* of which those marked * are printed and available. Numerous line drawings have also been made and will be utilized as occasion arises. The issue of coloured plates and lantern slides has been continued.

VI. Miscellaneous.

Correspondence. A total of 103 parcels of specimens, mostly of crop-pests, was received during the year for identification and advice, whilst 1,119 letters were received and 1,374 issued, but these numbers are exclusive of a large amount of routine correspondence.

VII. Insect Survey.

Steady progress has been made in additions to and arrangement of the collection. The whole of the collection of *Hymenoptera* has been rearranged in one series, so that all the information on any species or group is now available in one place. The same is being done with the Coleoptera, and other groups will be taken up as time and staff permit. The following collections were sent to specialists in the groups named and our thanks are due to them for the help afforded:—Chalcididæ to Dr. L. O. Howard, Formicidæ to Mr. W. M. Wheeler, Stylopidæ to Mr. Dwight Pierce, Dryinidæ to Mr. J. C. Crawford, Rhynchota to Mr. W. L. Distant, Coccidæ to Mr. E. Ernest Green, Noctuidæ and

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Pyralidæ to Sir George Hampson, Rutelidæ, Cetoniadæ and Dynastidæ to Mr. G. J. Arrow, Carabidæ to Mr. Andrewes, Histeridæ to Mr. George Lewis, Curculionidæ (part) to Mr. G. A. K. Marshall, Lucanidæ to Mr. F. H. Gravely, Microlepidoptera to Mr. E. Meyrick, Trypaneidæ to Professor M. Bezzi and their parasites to Professor Silvestri, and various Diptera to Mr. E. Brunetti.

Our thanks are due to His Excellency Lord Carmichael for a small named collection of moths from Darjiling.

Numerous sendings of specimens of insects have been identified for correspondents as far as possible.

Collections of flies, bugs, lice, ticks and other animals of interest as disease-carriers, made during the year at Pusa and whilst on tour, were transferred to the Imperial Pathological Entomologist.

VIII. Entomological Conference.

A meeting of the Entomological staff both of Pusa and the Provinces, was held at Pusa from 2nd to 8th February 1915. Similar meetings have been held previously, but not since 1909, and have hitherto been confined purely to the Agricultural Department. Opportunity was taken of the present occasion to extend the scope of the meeting to include others engaged in similar entomological work, and the Forest Zoologist, the Entomologist in the Indian Museum, and the Entomologist to the Indian Tea Association were also invited and attended and gave us the benefit of their experiences with various insects, which were of mutual interest. Besides these, Mr. E. Ballard, Government Entomologist in Madras, came from Coimbatore and Mr. E. J. Woodhouse, Economic Botanist, Bihar and Orissa, attended part of the meeting, whilst the Central Provinces and Bihar and Orissa each sent both their Entomological Assistants, and one came also from each of the following Provinces and States, *viz.*, Madras, Bombay, United Provinces, Assam, Baroda and Travancore.

An abstract of crop-pests had been prepared beforehand and specimens of each got out in show-cases in order that

there might be no doubt regarding the identity of any species under discussion. The list was worked through systematically and each insect discussed as regards its distribution, crops attacked, damage done, control, etc. The gaps in our knowledge respecting distribution especially, which revealed themselves during the meeting, were emphasized by the absence of the Entomological Assistants from Burma, Bengal, the Punjab and North-West Frontier Province, but in spite of this the meeting proved most valuable, especially to the Provincial Staffs, who are thereby helped to keep in touch with our work done at Pusa and that done in Provinces other than their own. It is hoped that similar meetings may be held regularly in the future.

IX. Programme of work for 1915-16.

This will follow generally on the lines of work of the current year and will include general investigations of crop-pests and especially of the pests of rice, sugarcane and cotton, of fruit-trees and of stored grain.

A commencement has been made of collection of information for a general book on the crop-pests of India and progress in this will be continued, as also in the publication of information regarding life-histories of pests and coloured plates, of which a large number are now ready for printing. Work and experiments in Silk, Lac and Bee-keeping will be continued, and new Insecticides and insecticidal methods tested as occasion arises. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

X. Publications.

The following publications have been actually published during the year under review :—

Books.

Some South Indian Insects, by T. Bainbrigge Fletcher. (Madras Government Press, Imperial 8vo., pages xxii + 565, 50 Plates and 440 text-figures.)

Bulletins.

No. 28. The Cultivation of Lac (Hindi edition), by C. S. Misra.

No. 39. Instructions for rearing Mulberry Silkworms (Bengali edition), by M. N. De.

No. 44. How to Improve Silk Reeling in Bengal, by M. N. De.

No. 46. Bee-keeping, by C. C. Ghosh.

No. 48. First Report on the experiments carried out at Pusa to improve the Mulberry Silk Industry, compiled by M. N. De.

Leaflets.

Maho (*Nephotettix bipunctatus*), by C. S. Misra (published by the Agricultural Department of the Central Provinces in English and Hindi and by the Balasore District Board in Uriya).

Practical Instructions for the Kollegal Mulberry Silkworm Rearers, by T. Bainbrigge Fletcher. (*Madras Dept. of Agri., Leaflet* No. I of 1914.)

Some General Methods of Controlling attacks by Insect Pests; Agricultural Methods; Mechanical Methods, by T. Bainbrigge Fletcher. (*Madras Dept. of Agri., Leaflets* III and IV of 1914.)

Miscellaneous.

Note on Tiger-Beetles from Coorg, by T. Bainbrigge Fletcher. (*Journal of the Bombay Nat. Hist. Soc.*, XXIII, 379.)

Report on Agricultural Entomology for 1913-14 for the Board of Scientific Advice for India, by T. Bainbrigge Fletcher.

REPORT OF THE IMPERIAL PATHOLOGICAL ENTOMOLOGIST.

(F. M. HOWLETT, B.A., F.E.S.)

I. ADMINISTRATION.

I was in charge of the section for the year, save for the period July, August, and September 1914, when I was absent on privilege leave and Hill recess. Mr. P. G. Patel was absent on privilege leave for 29 days and Mr. H. N. Sharma for one month and 20 days.

II. EDUCATIONAL.

No educational work was done. Mrs. Kilby and Mr. Awati worked in the laboratory for some time, the former at the reflexes of *Cimex* (*Clinocoris*), and the latter at the taxonomics of *Muscidae*.

III. RESEARCH.

There have been three main lines of enquiry :—

(1) A thorough investigation of the flies and other insects which breed in decaying or septic animal matter, including those that infest wounds and sores in domestic animals and man. Veterinary officers are being circularized for specimens of maggots, and the Pusa species have been under close observation for the last nine months. I have endeavoured to combine with the life-history observations an enquiry into the "chemotactic" reactions of the insects and of the parasites which evidently share them, but the chemical problems involved are such as require the assistance of a skilled biological chemist, who is unfortunately not available. The practical importance of an enquiry into these reactions is considerable, as a knowledge

of them would certainly simplify preventive and antiseptic measures.

(2) Energetic relations of insects: their consumption and economy of chemical energy under varying conditions. Mr. S. K. Sen is obtaining data for this investigation during my absence, in the form of food, oxygen, and water curves for the whole life-history of various insects. I hope subsequently to correlate this work with enzyme-investigations of the type recently carried out by Mr. Barnes at Lyallpur. Results of practical importance may or may not be obtained.

(3) The pure chemical substances responsible for the "chemotactic" reactions of the males of three species of fruit-fly have now been definitely and certainly ascertained. They are methyl-eugenol and iso-eugenol. Similar reactions in the case of a small Oscinid are produced by Isovaleric aldehyde. Analogous but not precisely similar cases are under observation.

The immediate practical value of this work is almost negligible; its ultimate value may be large, since it indicates the practical possibility of entirely new methods of insect-control. It is far and away the most important result yet achieved by the section.

IV. Miscellaneous.

(*a*) **Lice.** The lice of sheep and goats were investigated. A lime-sulphur spray or wash, followed by a spray of weak vinegar, was found to give excellent results. Internal administrations are being experimented with. On human lice the effect of extremely small quantities of mercury compounds was found to be very marked, though the way in which they act is obscure.

(*b*) **Bugs.** An attempt was made to elucidate the nature of the "biting-reflex" in the bed-bug. The enquiry proved difficult, but there were indications that the ventral

sense-organ was of importance; the work will be resumed at a later date.

(*c*) **Ticks.** *Ornithodorus savignyi*, a possible disease-carrier, is under observation.

(*d*) **Mosquitos.** A *Taeniorhynchus* and *Culex gelidus* have had their life-histories determined. Both are extremely troublesome to cattle, and *C. gelidus* breeds normally or very frequently in cow's urine.

The breeding-places of mosquitos in Pusa were carefully mapped in March, and some time later the Director gave facilities for an anti-mosquito campaign on "control-breeding" lines. This has been successfully carried on and I hope that my absence on leave may have no appreciable effect on the success of an experiment which opened auspiciously.

With a view to determining the influence of local waters on mosquito-breeding, experiments were made on the effect of equimolecular salt solutions on the larvæ. The results were of interest as indicating that an unexpectedly high percentage of lime in water is to some species distinctly beneficial.

(*e*) **Fruit flies.** The Ber fly, *Carpomyia vesuviana*, and its parasites were under observation for the year, and the life-history of *Dacus longistylus* was worked out. An attempt to check a very severe infestation of peaches by *D. zonatus* at Lahore failed completely, the attack having gone too far to save the crop. Spraying operations must be started as soon as peaches are just on the point of becoming ripe.

(*f*) **Other Diptera.** Rice in the Balasore district was seriously affected by *Cecidomyia oryzæ* and other insects. I investigated the part played by Cecidomyia; but found that the greater damage was being done by non-dipterous insects, mainly the Rice Hopper, and Mr. Fletcher thereupon took over the work. The life-history of three horse-flies (*Tabanidæ*) has been worked out, as also that of the very

curious Diopsid fly *Sphyracephala hearseyana*, though the habits of the adult are still obscure. The early stages of acalyptrate muscoids breeding in mushrooms have been obtained, but it is not known how these species spend the dry and hot part of the year.

V. Collaboration.

The usual amount of identification work was carried on; the Indian Museum was supplied with a considerable number of specimens to assist in the compilation of the "Fauna of India."

I interviewed the Director of Fisheries, Bengal, with reference to larvicidal fish in connection with control-breeding schemes.

In connection with the Kathgodam Surra work, a "pre-rains" survey of the area has been made for bloodsucking flies; this will be correlated with a similar survey made during the actual Surra season. I inspected the area in company with Mr. Shilston.

Arrangements have been made to assist Mr. Ballard in a chemical investigation of the sexual reactions of *Amsacta*.

I attended the 2nd Science Congress at Madras, and was pleased to note the increasing strength and authority of the organization, and the generally high quality of the papers read.

VI. Programme of work for 1915-16.

The three lines of enquiry mentioned under the heading "Research" in the above report will be continued. In the event of my going on leave my assistants will carry on Nos. (1) and (2) until my return. Sanction has been requested for the publication of a book as projected in last year's programme.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

(C. M. Hutchinson, B.A.)

I. Administration and Tours.

Charge. I held charge of this section during the whole year.

Establishment. Mr. J. H. Walton, the Supernumerary Agricultural Bacteriologist, was relieved of his duties to join his post in the Military Department on the 4th June 1915.

Mr. N. V. Joshi, the First Assistant, was on privilege leave for two months and 19 days with effect from 5th October 1914 and Mr. K. S. Vishwanatham acted for him.

Mr. Hardayal Singh, Assistant, was on privilege leave for one month and 12 days with effect from 19th August 1914.

Messrs. A. N. Bose and Hardayal Singh, assistants, were confirmed on the 26th May 1915 in their respective posts owing to the transfer of Mr. N. C. Basu to Bengal.

Tours. The following tours were made by me during the year 1914-15 :—

1. September 1914. To Calcutta to consult with the Excise Commissioner of Bengal, Bihar and Orissa and Assam on the subject of Bákhar and to investigate local conditions of rice beer distillation.
2. October 1914. To Shillong on Hill Recess.
3. November 1914. To Calcutta to interview Scientific officers of the Indian Tea Association and to inspect the Bengal Distillery Co.'s distillery at Konnagar.
4. March 1915. To Motipur and Peeprah Factory to arrange for carrying out manurial experiments with green manures.

II. Training.

Mr. Barkat Ali, Assistant to the Agricultural Chemist to the Government of Punjab, who was under training in this laboratory from 12th August 1912 to 13th August 1914, during the latter part of his training carried out an investigation on the bacteriological aspects of "Reh" soils from the Punjab and submitted a full and detailed report on this subject referred to below.

Mr. D. V. Bal, Assistant to the Agricultural Chemist, Central Provinces, was under training from 20th August 1914. Mr. Bal applied the method of biological analysis to samples of soils from Sind and carried out experiments in connection with the investigation of the action of bacteria upon nutrient matter in the soil and the occurrence of toxins in soils. He also isolated *Ps. campestris* from a specimen of diseased cabbage sent from Poona and from others locally obtained.

Mr. A. K. Bose, Assistant Chemist to the Indian Tea Association, Calcutta, worked in this laboratory from 13th February 1915. Mr. Bose was instructed in the method of biological analysis of soils and carried out experiments therewith on samples of soil from the Tea Districts as referred to in this report.

III. Soil Bacteriology.

Bacterio-toxins in soils. The work on bacterio-toxins in soils was continued and carried a stage further; it was found that the inhibition of nitrification occurring in soils under water-logged or semi-anaerobic conditions was not due merely to lack of the oxygen required for formation of the completely oxidized product, but to the action of toxins resulting from the activity of certain classes of bacteria which rapidly multiply under these conditions. That this toxic action was not due either to ammonia or carbon dioxide in excess was shown by the inhibitory action of water extracts of the toxic soil upon nitrification in normally aerated soil, and more conclusively by that of certain bacteria isolated from such soils, notably of one bacillus

(*Bacillus X*) the toxic action of which was found to be sufficient to interfere with the growth and activity of all other soil bacteria brought in contact with it or with its separated toxin in culture.

It was found that such toxins result from the decomposition of organic nitrogen compounds by bacterial action under semi-anaerobic conditions, and further proof that the inhibition of nitrification is not due merely to shortage of oxygen was afforded by the observation that, with the same air supply as was sufficient for complete nitrification of ammonium sulphate in soil, nitrification of oilcake containing the same amount of nitrogen was completely inhibited, nor did it commence when complete aeration was provided, until after the lapse of a considerable period (generally about two weeks although this varied with different soils) when the toxins formed had had time to become destroyed by oxidation, after which normal nitrification ensued. It was found in actual practice in the field that germination in a soil which had been water-logged was interfered with, and that the ensuing crop was consequently poor, nor was this remedied by application of nitrate of soda, although the use of superphosphate was successful. Laboratory experiments showed that rapid reduction of nitrate takes place in water-logged soil, a large proportion of nitrite being formed, and it seems probable that the toxins produced during the water-logged period would not only affect the germination and the growth of the seedlings but that the character of the soil complex resulting from the semi-anaerobic conditions which obtained at that time would be such as not only to interfere with nitrification but to promote reduction for just so long as this abnormal character persisted. The character of the soil complex and that of the decomposition products of organic matter resulting from its action must vary with alterations in moisture and oxygen content of the soil itself, and it is probable that the altered character may persist for some time after the special conditions which gave rise to it have disappeared. This point is under experimental

observation. It was found in the laboratory that superphosphate had a neutralizing action upon the toxicity to bacteria of extracts of certain soils and this was traced to the free acid; this result, however, was not sufficiently conclusive to allow of its use as a convincing explanation of the favourable action of superphosphate upon waterlogged soils, although this theory is supported by Meggitt's work in Assam, but will require further experimental investigation.

Ammonification proceeded at the normal rate in soil under semi-anaerobic conditions and was apparently not interfered with by the bacterio-toxins produced although the activity of such ammonifiers as *B. mycoides* is actually lowered by the presence of *Bacillus X.*; this latter organism does not appear to be universally present in soils; no concentration of ammonia above that in the aerated control was found nor was this gas given off by the anaerobic soil. The action of carbon dioxide in excess was eliminated by absorption with potash, as well as by the use of the soil extract as mentioned above.

A special experiment was made to test the action of the carbon dioxide formed in soil by bacterial action upon nitrification in that soil; under partially anaerobic conditions absorption of the carbon dioxide produced no effect upon nitrification in soil, either of oilcake or of ammonium sulphate; in this experiment, the observation was repeated that complete nitrification of ammonium sulphate took place under semi-anaerobic conditions in which no nitrification of oilcake occurred.

It appears therefore that in soils in which aeration is incomplete, as a consequence either of want of proper cultivation or of drainage, the decomposition of organic matter by such bacteria as thrive under these conditions will result in the production of toxins inhibitory of nitrification. It has also been shown that these toxins are destroyed by exposure to air and can be removed in water solution, so that the ordinary operations of tillage and drainage can prevent their accumulation.

Work with seedlings (wheat, oats, rice, indigo, maize, *dhaincha*, *jowar*), has shown that in high concentration, such as occurs in water-logged soils containing much organic matter, these toxins may directly affect growing plants especially seedlings, but this is an exceptional condition, whereas it appears probable that in normal fully aerated soils the toxins resulting from the ordinary metabolic activity of soil bacteria are oxidized at about the same rate as they are produced and no accumulation takes place. A very slight interference with the oxygen supply to the soil, however, will turn the scale in favour of accumulation of toxins and in consequence upset the natural equilibrium existing in the soil complex between the toxin-sensitive nitrifying organisms on the one hand and the apparently less easily affected reducing organisms on the other, thus resulting in indirect injury to the crop by interference with the supply of nitrogen as nitrate. In soil which has been flooded during the monsoon the toxins formed may persist long enough to seriously prejudice the growth of seedlings if planted too soon; such soil should be given as long a period of aeration as is possible before planting.

In order to ascertain the conditions under which such bacterio-toxins are produced in soils a great deal of work was carried out in isolating and determining the specific functions of soil bacteria, but the proper development of this line of enquiry would necessitate collaboration with a chemical specialist. The possible bacterial origin of the various organic compounds of a toxic nature which have been isolated from soils by such workers as Schreiner, Shorey, Skinner, Reid and others would be one of the problems involved. It was found that salts of some of the heavy metals such as copper had a decided influence in neutralizing the toxic action towards seedlings of extracts of soils kept under anaerobic conditions; precipitation of the copper as sulphide was prevented by the addition of potassium cyanide, these salts being present in very small quantities; (0·025—0·03 per cent. $CuSO_4$). It appears

probable that the discrepancies recorded between the observations of some workers upon the stimulating effect of such salts upon nitrification may be explained by reference to the fact that the cases in which contradictory results were reported were not comparable owing to the use of organic nitrogenous matter, from which toxins could have arisen, in one series, and ammonium sulphate in another.

An interesting case occurred in the field at Pusa in which the use of copper sulphate as a precautionary measure against attack by wire worms resulted in a large increase on the treated plot as compared with an untreated control although both were free from attack by wire worm.

It was found in the case of seedling maize and *jowar* grown in soil or sand and watered with extracts of soil made toxic by keeping the latter under semi-anaerobic conditions that the residual contents of the seed were attacked by bacteria which had multiplied as a consequence of the prevalence of such conditions and had been transferred with the toxic extracts; the result of this attack was the production of toxic putrefactive bodies in immediate contact with the seedling resulting in its death; this did not occur in presence of copper sulphate. Mr. Milligan, Imperial Agriculturist, who drew my attention to the abovementioned field result with copper sulphate, has pointed out the significance of this observation in connection with this case, and the importance of its bearing upon the vital question of successfully bringing a field crop through the initial stages of germination and growth especially in heavy soils. Experiments are being carried out to test the value of antiseptics in relation to the early stages of plant growth under varying soil conditions from this point of view.

The toxic action of nitrites upon growing plants was demonstrated both under sterile and ordinary conditions in water cultures.

Nitrification. Numerous experiments on nitrification in soils and solutions were carried out and much valuable information on the subject obtained. This was especially the case in connection with biological analysis of soils from

various parts of the country, carried out for the most part by Assistants of Provincial Agricultural Chemists undergoing training in this section. Mr. Barkat Ali, Assistant to the Agricultural Chemist to the Government of Punjab, made a valuable biological analysis of Reh Soils from that province showing that although such bacterial activities as are essential to nitrification are practically non-existent in Reh Soils, this condition is completely altered by washing out the excess of salt. Mr. D. V. Bal, Assistant to the Agricultural Chemist, Central Provinces, tested the nitrifying power and capacity of certain soils from Sind which had undergone differential treatment in the field; this was found to vary considerably as a consequence of treatment. Interesting differences in comparative immunity shown by the nitrifiers in these soils to the inhibitory effect of partial anaerobic conditions as compared with the nitrifying agents in Pusa soil were observed, nor was the addition of lime beneficial in this respect. Nitrification in tea soils from different districts was studied by Mr. A. K. Bose, Assistant to the Scientific Officer to the Indian Tea Association; here very marked differences in nitrifying power between different soils, were found with varying results from the application of lime, and varying optima for water. Further experience with the method of biological analysis of soils has shown its value in elucidating soil problems and has made it possible to reduce it to a simple set of concurrent experiments.

The observed influence of toxins upon nitrification has been referred to above.

Nitrate formation in field plots under different crops has been under observation; grass has been found entirely to prevent accumulation of nitrate in the soil in which it is growing; this would have some bearing upon the action of grasses upon fruit trees, as the absence of nitrates must mean either that nitrification is inhibited or that the grasses take up the nitrate as rapidly as it is formed, or that in grassed-soil reduction takes place at least as rapidly as oxidation.

The effect of various trees upon nitrification due to the fall of their leaves upon the ground was studied and considerable differences were observed.

The optimum amount of organic matter as oilcake containing 5 per cent. nitrogen for nitrification in Pusa soil was found to be about 1 per cent. of soil weight. At a concentration of 2 per cent. ammonia formation was so rapid as to result not only in inhibition of nitrification but in loss of nitrogen as ammonia gas; the free ammonia also brought organic matter into solution and made it necessary to abandon the use of the tintometer for estimation of nitrates and to use the aluminium reduction method, which was found more convenient and reliable for this particular purpose than the zinc-copper couple. Indications were obtained that the prejudicial effect of organic matter upon nitrification is in many cases due to the rapid multiplication of toxin-producing bacteria consequent on its presence.

The effect of temperature on nitrification in Pusa soil was tested, the optimum being found to be near 35° C.; no nitrate was formed at 40° C., nor did nitrification take place in soil which had been kept at 40° C., when its temperature was afterwards reduced to 30° C.; further work on this point is being carried out to determine the cause of this apparent lowering of the thermal death point.

A series of experiments was carried out to determine if possible for what reasons on adding as solids such bacterial food stuffs as oilcake or sugars, to a live soil, the evolution of carbon dioxide resulting from bacterial action should rise in rate for a few days but fall again rapidly to a minimum long before exhaustion of the food supplied could be called upon to account for such diminution in activity. Reasons were found for thinking that this result, invariably obtained when solid nutrients were added to soil, was due in part to auto-intoxication by the soil bacteria, and in part to the purely physical facts of the case, depending upon the ratio between the superficies and the cubic contents of the particles of organic matter involved, and the possible protection against solution by

bacterial enzymes afforded by the superficial layer of altered material resulting from their first attack. This argument was strengthened by the observation that in nutrient solutions the fall in rate of evolution of carbon dioxide is much less sudden than where solid particles are concerned. The rate of formation of carbon dioxide is materially affected by the size of particles supplied. Partial sterilization of the soil sufficient to eliminate protozoa does not remove this difference.

Green Manuring. Owing to the difficulty of obtaining even areas of land for field experiments on the farm, it was arranged to take in a comparatively small area of one acre adjoining the outside laboratory of this section; this was divided into 24 plots of equal size and experiments in triplicate laid out for the *kharif* and *rabi* crops of 1914-15; the first was merely a crop of *sanai* (*Crotalaria juncea*) over the whole area; this was applied as green manure, variations in the method of application and their effect upon the succeeding *rabi* crops, oats and tobacco, being studied. As was expected, however, unevenness in this area made it impossible to draw definite conclusions from the experiments as a whole although certain deductions could be made from individual cases; these will be dealt with in the current report on green manuring. Some of the more interesting conclusions were drawn from the use of *seeth* made from *sanai* (*Crotalaria juncea*) the utilization of which had been suggested owing to the difficulty in obtaining indigo *seeth* consequent upon the reduction of area under this crop. It was found that the *seeth water* used in making the *seeth* was roughly equal in manurial value to the *seeth* itself in the case of the *rabi* crop (oats), but that in the residual effect on the succeeding *kharif* crop (maize) the *seeth*, as was expected, proved greatly superior to the *seeth water*. In the case of two areas under tobacco, one with normal and the other with comparatively low moisture content in the cold weather the effect of *seeth* as compared with green manure (*sanai*) ploughed in, in the ordinary way, was greater in the dry area. The differences produced

by green manuring in the rate of ripening both of the oats and of the tobacco were very marked. The effect of superphosphate in conjunction with green manure on the *rabi* crop was marked in soil with good moisture, but inappreciable in plots where the water content was low and the soil itself poor. A large number of observations were made on the changes going on in *seeth* during and after fermentation; it was concluded that the value of this material as a manure depends upon numerous factors of which its nitrogen content is the principal; at the same time great differences in the results may be obtained by proper or improper methods of preparation and application, especially the latter, as large quantities of toxic bodies are produced as a result of the semi-anaerobic conditions obtaining during the early stages of its manufacture, and can totally inhibit root growth if allowed to remain in the soil, being specially injurious to plants in the seedling stage. The time of application appears to be more important than the manner of preparation although these should be interdependent. In the meantime it will be necessary to crop the plots for some time without individual treatment and gain some knowledge of the extent of local variations amongst them. This seems especially necessary in the case of green manuring experiments the results of which are not likely to become strikingly obvious as quantitative differences in the succeeding crop of such an order as to carry them indubitably beyond the range of experimental error.

Studies were made of the development of root nodules on various leguminous plants with special reference to the depth below the surface at which they are formed, the effect of variation in the soil upon their vertical position, and the relation between their development and the age of the plant. With regard to this last, in the case of sanhemp (*Crotalaria juncea*) it was clear that each nodule had its own life-history independent of that of the plant, forming, developing to maturity, and finally shrinking and drying up to an empty shell; cultures and sections from nodules at various stages showed coincident changes

in the conditions of the bacteria and bacteroidal tissue. Nodules in all these various stages of development could be found at the same time on the same plant. Indications were obtained that nodule formation did not take place at that soil level at which most vigorous root growth was found, but tended to occur chiefly where the ratio of air to water was higher than was consistent with maximum root development. A characteristic difference in the character of growth was observed between roots in clay and those in sand, with intermediate variation in mixtures of the two, and similar changes where the plants were grown in alternate layers of these soils. It was remarkable that even in pure sand, nodule development was restricted to a comparatively shallow surface layer very slightly deeper than that found in the case of pure clay.

Sporadic development of nodules, insignificant in number, occurred at deeper levels.

The most universally prevalent characteristic was the fact that at least 90 per cent. of the nodules present at any one time were found on, or very closely adjacent to, the main stem, this being apparently due partly to the fact that such nodules had a longer life than those formed on more distal portions of the root, showing indeed the specific morphological characters associated with their host, and also in part to the fact of this position being coincident with the conditions of aeration which appear to favour their growth. An alternative hypothesis might suggest the importation of the specific *radicicola* organism by the seed and its consequent occurrence in the soil only in the neighbourhood of the latter; this, however, does not appear a probable explanation in view of the indigenous character of the legumes under observation. The general suggestion would be that nodule formation took place more readily in the earliest stages of the growth of the plant owing to the lower power of resistance to bacterial invasion which the latter possesses at that time. Rootlets of a similar age but formed at a later period of growth appear to be less readily invaded.

Azotobacter. Mr. Walton completed the initial stages of his work on *Azotobacter* in Indian soils, the results of which are being published in a Memoir. The preliminary survey showed the occurrence of *Azotobacter* in Indian soils of widely divergent type and situation; the variations in the organism from different localities were not sufficient either in morphological or physiological character to suggest differences of species. Fixation of nitrogen and its increase in amount as a consequence of added carbohydrates was demonstrated in soils in the field. Further work was projected on the symbiotic relationships between *Azotobacter* and soil algæ, some evidence having been obtained of the widespread and highly important nature of this natural source of soil nitrogen, but this has been temporarily abandoned in consequence of the appointment of Mr. Walton to a commission in the Indian Army Reserve of Officers.

IV. Special Enquiries.

Fermentation Organisms. The work on Bákhar was made the subject of a Memoir which was submitted for publication in April. The relationships between the amylo ferments and the Saccharomycetes involved in this question are still being studied.

Yeasts of the cerevisiæ type severally characteristic of the fermentation of *mahua* and molasses were separated from wild types present and supplied for trial to various firms of distillers; no conclusive reports have been received so far, but in the present condition of this industry in India it seems unlikely that much progress will be made of the kind essential for success in Europe, owing to the lack of expert knowledge in the distilleries. The success of the fermentation appears to depend upon its rapidity and consequent comparative freedom from bacterial or other contamination, and this rapid fermentation itself depends upon the use of a large quantity of active yeast; it is therefore upon the successful production of the "mass culture" of yeast that efficiency depends and as the only

methods of effecting this, so far as I know, in India are merely wholesale imitations of European practice, it is not to be expected that total disregard of the very large differences in the conditions under which growth of the yeast takes place in such widely different climates, will lead to any high standard of efficiency. On the other hand, it does not appear probable that any great experience or technical knowledge should be required to make successful modifications and adaptations of European methods to Indian conditions, but some, at least, is essential.

Saltpetre. Experimental work was carried on during the year in order to obtain some knowledge of the biological factors involved in the production of saltpetre in the soils of Bihar. Information was sought for on the following points:—

(1) Why does this industry flourish in particular localities?
(2) Could it be extended either in the places where it is already established or into other districts?
(3) Could the methods of recovering the nitrate from the soil be made more efficient?

The enquiry is still in an early stage, but it seems clear that the leading factors in determining the localities in which this industry can flourish are (1) a high percentage of lime in the soil, (2) suitable climatic conditions for (*a*) nitrification of organic matter, (*b*) accumulation of the nitrates formed.

These conditions are fulfilled in several districts throughout India including the Punjab and the United Provinces but it is in Bengal and especially in Bihar that they are most favourable. It has been ascertained that nitrification goes on during the monsoon in soils containing much nitrogenous organic matter such as occurs in the neighbourhood of villages, and that concentration of the nitrates formed is prevented by the rainfall which carries them down, and allows production to go on in the soil stratum in which conditions of food supply and aeration

favour bacterial action, which would, however, be interfered with by accumulation of nitrate beyond a certain concentration. Such a concentration is found in some of the saltpetre earth collected for extraction by the *nuniahs* and as it is of an order many times greater than that necessary to inhibit nitrification, it is clear that it has not been produced *in situ* by this process, but has been arrived at by the evaporation of weak solutions of nitrates from the soil surface either in the field or on the walls of houses.

The *nuniah* collects *nuni-mati* or saltpetre earth from haphazard sites selected with reference to the accumulations of nitrogen characteristic of village sites and cattle sheds; hence he is dependent on uncontrolled supplies of raw material and any expansion of the industry could only be effected either by introducing the *nuniah* into hitherto unexploited districts or by artificial nitrification of nitrogenous organic matter which would otherwise serve some other purpose. An attempt is now being made to discover the extent to which the carrying out of this latter alternative is feasible. Local enquiry has elicited the fact that the *nuniah* does not generally make his business pay until the second or third year, which he attributes to the fact that the amount of nitrate obtained directly by extraction from the earth collected in the neighbourhood is insufficient on the average to pay expenses, and it is only when the accumulation of residual earth (which after extraction is carefully stored) is sufficient in quantity or suitably matured for a second extraction, that paying quantities of saltpetre are obtained.

If this information proves to be reliable it is obvious that a great deal can be done for the industry simply by ensuring that the time spent in maturing the store of residual earth shall be employed to the best advantage, *i.e.*, that the optimum percentage of organic matter and moisture shall be present, that no leaching by rain takes place, and that nitrification shall not be interfered with by the addition of excessive quantities of salts in solution in the "mother liquor" remaining after concentration,

which it is the *nuniah's* practice to return to the heap of residual earth. This practice may be harmless or even valuable up to a point, after which it must tend to lower the rate of nitrification.

The addition of wood ashes is another practice which probably might be modified with advantage after examination. The addition of organic matter will no doubt prove the most likely source of possible improvement; experiments on this point on a considerable scale are in progress.

Potato Rot. The enquiry into this subject referred to in my report for 1913-14 was completed and a Memoir on the subject was submitted for publication. It was shown that the rotting of potato tubers in store was in many cases due to the action of bacteria common in Indian soils; the conditions under which such bacteria were able to attack the tubers were described and preventive measures recommended. The practice of storing tubers in sand as a protection against potato moth appears to be responsible for many cases of rot in consequence of the increased chances of moisture condensation due to the use of earth instead of sand or imperfect ventilation.

V. Programme of work for 1915-16.

Major Subjects.

(1) Nitrogen fixation by Azotobacter.

(2) Nitrification of organic matter; including conditions severally favourable to ammonification and nitrification.

(3) Green manuring with special reference to organisms responsible for breaking down of buried plant tissues and their conversion into humus, ammonia and nitrates.

Field experiments in green manuring will be carried out in the Bacteriological area attached to the outside laboratory.

(4) Activity of soil bacteria with regard to the rendering available of phosphates and other

mineral plant-foods. This subject will be studied with special reference to the fertilizing action of superphosphate in conjunction with green manures.

(5) Soil Toxins. Bacterio-toxins occurring in soils; their influence on nitrification and the conditions conducive to their formation and destruction; this study is especially connected with the practice of green manuring and the use of organic manures in badly drained soils.

(6) Study of conditions under which saltpetre is formed in Bihar soils.

(7) Biological analysis of soils; a further study of the best means of carrying out this method of investigating soil conditions; this subject forms a principal part of the training of students in this section, the earlier stages being especially designed to allow of familiarization with the methods of obtaining information as to the biological conditions in a soil without undergoing a course of training in purely bacteriological technique.

Minor Subjects.

Study of organisms connected with fermentation.
Such cases of bacterial disease of plants as may arise.

VI. Publications.

The following publications were issued during the year :—

(1) A New Nitrite-Forming Organism, by N. V. Joshi. *Mem. Dept. of Agri. in India, Bact. Ser.*, Vol. I, No. 3.

(2) An article on "Turf," by C. M. Hutchinson. *Agricultural Journal of India*, October 1914, Vol. IX, Part IV.

(3) Report on Agricultural Bacteriology for 1913-14 for the Board of Scientific Advice, by C. M. Hutchinson.

REPORT OF THE IMPERIAL COTTON SPECIALIST.

G. A. Gammie.

I. Charge and Tours.

I held charge of the appointment throughout the year.

Tours. In October, I visited the United Provinces and toured with the Deputy Directors of Agriculture and Economic Botanist.

In November, I visited the Central Provinces and travelled with the Deputy Director of Agriculture and Economic Botanist.

In December, the special trials of Egyptian and other cottons were investigated at Gokak in the Southern Mahratta Country.

In January and February, I was in Gujerat with the Deputy Director of Agriculture working out the characteristics of certain local cottons.

In March, I was in the Southern Mahratta Country working out some details with the Deputy Director of Agriculture.

II. Cotton in the Provinces.

United Provinces. *Cawnpore.* Mr. Leake's No. 7 is *Gossypium indicum*, var. *Mollisoni*, according to me. This is highly reported on by the trade and it certainly looks very promising. Here the glabrous form of Upland Georgian cotton is known as Dharwar-American and the hairy leaved one as Cawnpore-American.

Conformably with our experience the latter is the more suitable to grow, as it is hardier than the smooth-leaved form, which is also peculiarly subject to insect attacks.

In Dr. Parr's Circle, the Cawnpore-American is surpassed by *Bhuri*, an acclimatized Upland from Chutia

Nagpur. The Cawnpore-American at Cawnpore and elsewhere was originally of many types, but Mr. Burt has now satisfactorily purified it. As the result of spinning trials the cotton is said to be slightly superior to Middling American in all respects except that it has a proportion of short fibres, a character which will probably be eliminated by the methods of selection now being carried on. An increase of 2 per cent. in the ginning percentage is also possible and desirable.

Kalai. Here Mr. Leake has a well-arranged farm for growing his types and selections on a fairly large scale. This farm will serve as a centre of distribution of a pure supply of seed of the following varieties :—

(1) A white-flowered indigenous cotton fit for the use of the eastern parts of the Provinces.

(2) No. 7 or the white-flowered *indicum* which is being successfully introduced into Bundelkhand.

(3) A red-flowered cross which will eventually replace the inferior but highly productive white-flowered cotton of this tract.

(4) A large bolled variety of smooth-leaved Upland from Persia. This is not promising and it will probably have to be abandoned.

I visited several localities in which Bhuri cotton is grown, in the company of Dr. Parr and I agree with him in thinking that it is quite suitable for this tract.

Cotton operations in the United Provinces can be summarized as follows :—

In Mr. Burt's Division. The introduction of Cawnpore-American into localities with good soil and irrigation; the extension of No. 7, throughout Bundelkhand; the introduction of an early-maturing variety for the eastern parts. This, at present, is being evolved by Mr. Leake.

In Dr. Parr's Division. The present extension of the white-flowered indigenous cotton in place of the prevalent

mixture. This he hopes to supplant in time with Mr. Leake's improved red-flowered cotton; the extension of *Bhuri* as a higher class cotton in the favourable localities; a possible improvement of one yellow-flowered indigenous cotton at least.

Distribution of improved seed. It is satisfactory to note that this has received careful attention and I approve of the method now being worked out by Dr. Parr in the Western Circle. In this there are a large number of spring wells, giving a discharge of from 8,000 to 20,000 gallons an hour. It has been shown that this water can be raised more cheaply by oil-engines and centrifugal pumps than by bullocks. As a result, a large number of *zamindars* and cultivators are putting down pumping plants on their wells. Government is assisting by giving *takavi* for this purpose. These installations are doing very useful work directly, that is, in pumping water cheaply. They are also going to prove extremely useful in facilitating the supply of improved seed introduced by the Department. I will confine my further remarks to the needs of the cotton crop. Many of these oil-engine owners are being induced to put down cotton gins. At present it is hoped that for every one hundred thousand acres of cotton grown, there will be about twenty-five oil-engines, each with a cotton gin attached. The oil-engines vary in size according to the amount of water in the wells and the depth of the water from the surface, but each will command on an average about fifty acres of cotton, that is to say, there will be twenty-five seed-farms each growing fifty acres of cotton or a total of 1,250 acres. The produce of this area will sow about 18,750 acres in the following year so that these seed farms will supply seed to the total area of one hundred thousand acres once in about five years. No hard and fast rule need be laid down. If it seems advisable to cover the area more often, many more centres where pumping installations are working, will be available. To supply the twenty-five seed farms or the total private seed-farm area of 1,250 acres, an area of eighty acres will be

required. This will be entirely under the control of the Agricultural Department.

The private seed-farms will gradually establish a reputation as suppliers of good seed. The crop will be grown, the ginning done and the seed supplied at first under some supervision from the Agricultural Department. But it is hoped that gradually supervision will become unnecessary and a private seed supply agency will grow up and relieve the Agricultural Department of what is at present one of its most onerous duties.

My assistant, Mr. Mankad, also independently visited the Provinces and furnished notes supplementary to my own. The types grown at Cawnpore under numbers are thus understood by us.

I. *G. obtusifolium*,
II. *G. herbaceum*,
III. *G. arboreum*,
IV. *G. indicum* (true) with yellow flowers,
V. *G. neglectum*, broad-lobed, yellow flowered (var. *Malvensis*),
VI. *G. neglectum*, broad-lobed, white-flowered, with branching habit,
VII. *G. neglectum*, broad-lobed, white-flowered (*G. indicum* var. *Mollisoni* according to us),
VIII. G. *neglectum*, narrow-lobed, with yellow flowers (var. *vera*),
IX. *G. neglectum*, narrow-lobed, white-flowered (var. *rosea*),
X. Assam or Kil cotton,
XI. G. *sanguineum*, with pink flowers.

The Economic Botanist has numerous crosses and one between *arboreum* and *Mollisoni* has been worked up to a field scale. His object is to produce, if possible, a type possessing the following characters :—(*a*) early maturity, (*b*) heavy outturn, (*c*) high ginning percentage, (*d*) superior quality of fibre, (*e*) cotton with naked seed. To achieve the last object he has selected a long fibred type of Chinese cotton which has naked seeds, and this is used for crossing.

Type VII comes to maturity early and gives an average outturn of 800 lb. seed cotton with a ginning percentage of 33 to 34 and staple averaging three-fourths of an inch.

The cross *arboreum* × *Mollisoni* gives an outturn of 600 lb. seed cotton, with a ginning percentage of 33 and staple of about three-fourths of an inch. This cross, which resembles *Sanguineum* in all respects, is now in its fifth year and it is intended to start distributing its seed.

At the Kalai Farm Type VII is grown on 35 acres.

The crosses put out are:—(*a*) *arboreum* × *roseum*, purified white-flowers; (*b*) *arboreum* × *roseum*, purified yellow-flowers, seventh generation; (*c*) *arboreum* × *roseum*, purified pink-flowers; (*d*) *arboreum* × *indicum* var. *Mollisoni* (Type VII), pink-flowers, narrow-lobed; (*e*) *arboreum* × *Mollisoni*, red-flowered, purified.

At Cawnpore, under Mr. Burt, Black Rattler and other fancy types of American cottons have been tried with fresh seeds obtained from America but so far they show no promise.

Bhuri seemed hardier and better in growth than Cawnpore-American and also higher in ginning percentage. The fibre of both, however, seemed weak.

On the seed farm *roseum* appeared more promising than either Type VII or Cawnpore-American.

At Aligarh, the white-flowered local cotton (*roseum*) seemed better than Type VII. This gives an average outturn of 800 lb. seed cotton, with a ginning percentage of 37 to 38. The cultivators in this Circle have been independently selecting white-flowered cotton seed. It is possible that in the future the whole of the cotton in the tract will consist solely of this.

The conclusions arrived at by Mr. Mankad are that (1) the local cottons are the same as those of Sind (a tract with which he is familiar), but *less hardy*. (2) Of the pure types, *indicum* var. *Mollisoni* and *roseum*, the former produces the better staple, but is poorer in ginning percentage, (34) the latter gives a very high ginning percentage and it

is hardier. (3) Of the crosses, *arboreum* × *Mollisoni* is promising. It resembles *sanguineum* in all respects. Mr. Mankad has not personally seen the Mooltan cotton but from samples of it received from Lyallpur, it appears to him that cotton of this cross is lacking in *colour* although it has a finer staple. Of the American types, Cawnpore-American and *Bhuri*, he does not think that either will really succeed in this tract.

Central Provinces. At Telinkheri Farm the most promising selection is a cross between *Bani* and *roseum*.

The selections of *roseum* vary in percentage from 41 to 43.

Cambodia seems to ripen too late for this tract.

Allen's Long Staple is not promising.

At Tharsa, there is a very well-grown plot of *roseum* and there is no particular reason why it should not do well in this locality. At Chhindwara, an Upland cotton has produced beautiful bolls in Mr. Lawrie's orchard and that gentleman has promised to save the seed and put it out on a large scale. At the Seoni Farm the cottons are early ripening *Chapra* and *Saugar*. They are most suited for this tract. They are also being grown to demonstrate the advantages of drilling over broadcasting which is the local method. It is to be hoped that the people will follow the excellent examples shown on this farm. The *kamdar* is a particularly intelligent man and has a very clear idea of the nature and value of the experiments under his charge. At Sindewahi, Cambodia and *roseum* are being tried under irrigation on *wardi* soil. This is the third year of the trial on a large scale. Last year, under irrigation and manuring, the crops were 1,000 lb. of Cambodia and 1,200 lb. of *roseum*. The cotton was of a good quality. So far the cultivators hesitate between the claims of rice and cotton. This is not really a cotton-growing tract and it would only partially replace rice in the event of cotton prices ruling high. Mr. Clouston has hopes of a cross between *deshi Lahore* and *roseum*. It is valued at $8\frac{1}{2}$ per

cent. more than Hinghanghat. *Roseum* everywhere is a strong competitor against *Bhuri*, which will be restricted ultimately to wilt-infected areas.

Cotton from the Sindewahi Farm was reported on as follows by Messrs. Tata and Sons of Bombay :—

Roseum. Compared with roseum grown on the Akola Farm, it is a little longer in staple and softer in feel, though the class is dull. Can spin up to 12's. Value Rs. 190 per candy or equal to the price of Akola cotton on the day.

Bani × *Deshi Lahore.* Seems to be a little better in staple than the same variety sent from the Akola Farm, though not so bright as the other. Can spin up to 22's and 24's. Value Rs. 240 per candy.

Cambodia. Compared with *bani* of the Akola Farm it is weaker in fibre and a bit shorter in staple. Can spin up to 30's. Value Rs. 260 per candy.

An analysis of these valuations based on the acreage outturn of seed cotton and percentage of cotton to seed shows that in actual values the three varieties from Sindewahi stand as follows :—

Roseum, Rs. 65 per acre.
Cambodia, Rs. 59 per acre.
Bani × *Deshi Lahore*, Rs. 40 per acre.

On the same basis nine varieties of cotton received from the Akola Farm stand as follows :—

	Per acre Rs.
(1) *Bani* × *Deshi Lahore*	58·14
(2) *Gossypium neglectum*, var. *rosea* . .	53·3
(3) *Gossypium neglectum*, var. *Cutchica* .	50·2
(4) *Gossypium neglectum*, var. *Malvensis* .	33·14
(5) *Gossypium hirsutum*, var. *Bhuri* . .	32·6
(6) *Gossypium neglectum*, var. *vera* . .	31·4
(7) *Gossypium indicum* (Bani) . . .	30·10
(8) *Gossypium neglectum* (Berar Jari) .	29·5
(9) *Gossypium neglectum* (Saugor Jari) .	26·13

Bombay: Southern Mahratta Country. After my visit to Gokak Agricultural station to inspect and report on some interesting experiments conducted by Mr. Kottur, I submitted the following note.

Egyptian cottons. In 1908-09, Abassi was grown. The plants were very vigorous and tall and gave good cotton. In 1909-10, the plants were stunted and were attacked by red-leaf blight. In 1910-11, Abassi and Meta-Fifi were both tried with seed procured from Sind. The plot became water-logged, the plants were attacked by red-leaf blight and the outturn was small. In 1912-13, the plants were moderate. This year they have done better. Mr. Kottur thinks that, by selection, he can finally make the cultivation of Egyptian cotton in Gokak a success and, as he is endowed with the spirit of independent research, I recommended that he should be encouraged to persevere. In this tract, cotton is grown under irrigation on four thousand acres out of an area of forty thousand acres, so in the event of success a large area could be put out under a high class cotton.

Cambodia cotton suffers from red-leaf blight. It gives a good yield under a low rainfall and a bad one under a heavy rainfall. The crosses from Nadiad-Abassi × Bourbon, Bourbon × Abassi, Abassi × Cambodia are not promising and they are becoming later in ripening. Broach cotton is only fairly satisfactory. Selected Kumpta does well. The local variety *kumpta* is the most to be depended upon under all conditions. Under irrigation it yields up to six hundred and seven hundred pounds of seed cotton per acre.

The following observations made by Mr. Kottur on Meta-Fifi sown from seed imported from Egypt by me are interesting as showing differences caused at once by a new environment :—

(1) The height of the plant, instead of being eight feet, is from four to five feet.

(2) Instead of bearing numerous long, upright, basal branches, it has none or very short ones.
(3) Instead of the fruiting branches being produced only above the middle of the plant they are produced from one-third the height of the plant upwards.
(4) The plants are glabrous.
(5) The teeth of the bracteoles, instead of being short, are long.
(6) The colour of the flower is light yellow and not bright lemon yellow.
(7) The length of the petals, instead of being two inches, is one and a half to one and three-quarters inch.
(8) The bolls in most cases are not well-filled, the tops being often blunt.
(9) The number of cells (locks) is three in all cases.
(10) The staple is one-half to one inch long.
(11) The covering of the seed varies. It is green-tufted at both ends, or only so at the tip; brown-tufted at both ends; brown-tufted at the tip only; and almost naked.

Although the seed was procured from a reliable source in Egypt it is quite probable that I may not have been supplied with the real article, and all the above differences may not arise from altered conditions.

The opinion of Messrs. Tata on a sample of Egyptian cotton from Gokak Farm is as follows:—

It is a long stapled excellent cotton having all the characteristics of Egyptian. We have no basis to value this cotton.

Broach cotton at Dharwar. There is now the eleventh generation of Broach. The percentage of cotton to seed has fallen to 29. The crop ripens almost as early as that of Kumpta. Mr. Kottur has detected eight different shapes of bolls in the Broach cotton. He is to sow the seeds from each of these separately so as to ascertain whether any differences will ultimately occur in ginning percentage and other factors.

There are four experiments being conducted on this farm in connection with Broach cotton :—

(1) *Shevri* (*Sesbania œgyptiaca*) and *jowar* used as wind-breaks. Owing to the absence of easterly winds this year the results are indefinite. As it has had effects on contiguous crops, *shevri* should be removed and the *jowar* alone kept on.

(2) To test the prevailing idea that *jowar* follows Kumpta more profitably than it does Broach. (Last year's conclusion served to prove that *jowar* follows Broach just as well as it does Kumpta.)

(3) Wilt disease. It has only appeared this year and is increasing in Broach cotton, especially in that from the new seed.

(4) Deep *versus* shallow ploughing.

Subsidiary tests are in progress to find out whether *jowar* sown in August will come on as quickly as that sown in July, the difficulty at present being that the cultivators say they cannot get their fields ready in July for sowing *jowar* after Broach cotton.

Very little of the Broach cotton produced by members of the Agricultural Association ranked as first class in the auction. They should not be discouraged by this failure but repeat the experiments in more carefully selected areas.

The members of the Association have also imbibed the idea that Broach has a bad effect on the succeeding *jowar* crop. The experiments on the farm (already referred to) may reassure them on this point.

Mr. Mankad has the following note on the sale of Broach cotton which took place on the 16th May 1915 at Dharwar :—

"In all, 39,000 lb. of seed were distributed covering an area of about 2,500 acres (10,000 lb. fresh seed imported from Navasari and 29,000 lb. from the special class of the auction sale of last year).

The cultivation of this cotton is chiefly confined to Dharwar, Hubli, Bankapur and Haveri Talukas of the Dharwar District and the Sampgaon Taluka of the Belgaum District.

Sowing took place in July as well as August. Heavy continuous rains spoiled especially the black soil area bordering Malad so much so that the crop had to be grubbed up and the area had to be put out under wheat. The shedding of the leaves was tremendous and the bolls dropped down; the opening was also unsatisfactory. The average yield in this area, *viz.*, the black soil area bordering Malad, was very disappointing—50 lb. per acre only.

In the eastern portion of the black soil area bordering Malad the yield per acre averaged 200 lb. *kapas*. The crop did not suffer much in these parts as the rains were not very heavy. The late rains in January and February were most unfavourable for all cotton crops and especially to Broach. The excessive moisture at that time induced the plants to throw out more of leafy and woody growth and the bolls already formed did not open at all.

Picking was very leafy. The local cotton Kumpta was also a six anna crop.

The total number of *dhokadas* of Broach cotton received at the Depôt was 1,274.

The cotton was graded in six classes according to ginning percentages and the following prices were obtained per *naga* of 1,344 lb. *kapas*:—

Class	Ginning per cent.	Price per *naga*
		Rs.
Special	*Nil*	*Nil*
1st	33·5	150
2nd	32·5	143
3rd	31·5	136
4th	30·5	127
5th	29·5	124
6th	Rejected Broach	110

The local cotton Kumpta on the day stood at Rs. 107 per *naga*.

In addition to Broach cotton 438 *dhokadas* of Kumpta cross having a ginning percentage of 27·5 and 26·5 got Rs. 110½ and Rs. 108½ respectively per *naga* of *kapas*.

The prices were offered from the point of ginning percentages. Broach cotton graded in Class IV was stronger and better in colour than that of Classes I and II.

The ginning percentage of Kumpta cross was very low this year owing perhaps to the deterioration of the variety due to local seeds being used every year. No seed was therefore bought back this year. Similarly the ginning percentage of Broach was low this year.

It will be seen from the statement that not even one *dhokada* has come in the special class. The number of *dhokadas* even in the first class was very small, *viz.*, 52.

All the Broach cotton was purchased by Mr. Jijibhai Ardeshiar Dewecha who was specially deputed by Messrs. Tata, Sons & Co., Bombay.

It is proposed to get about 3,000 ℔. fresh seed from Navasari and to obtain all seed from the first class of the sale at 40 ℔. a rupee (this will give about 10,000 ℔.) so that in all there will be about 13,000 ℔. for distribution this year. From the quantity of seed intended for distribution it seems that the area under Broach cotton will considerably fall this year."

Messrs. Tata make the following valuations and remarks on six samples sent from Dharwar :—

Serial No.	Name of Variety	Remarks
1	Kumpta from plot 608	No. 2 is in every respect superior to No. 1. No. 1 can spin up to 24's and No. 2 can spin up to 32's. Value No. 1, Rs. 230. No. 2, Rs. 245.
2	Kumpta selected for quality.	
3	Kumpta cross	No 3 is superior to No. 4—especially in strength of fibre. Can spin up to 24's. Value No. 3, Rs. 240 and No. 4, Rs. 235.
4	Kumpta × Ghogari	
5	Broach first generation	No. 5 is decidedly superior to No. 6. No. 6 has much deteriorated. No. 5 can spin 40's. Value Rs. 260. No. 6 can spin up to 30's. Value Rs. 240.
6	Broach 11th (last)	

Basis of prices per candy of 784 lb. on 21st July 1915 :—

	Rs.
Kumpta (mixed)	210
Kumpta (pure)	230
Navasari	260
Surat	240
Broach	220
Saw-ginned	215
Cambodia	240
F. G. Mathia	160

By analysis of the market valuation and acreage on them these samples stand in the following order :—

	Value per acre Rs.	A.
(1) Kumpta Cross	61	9
(2) Kumpta selected for quality .	56	3
(3) Broach (11th generation) . .	44	11
(4) Kumpta (from plot 608) . .	43	11
(5) Kumpta × Ghogari . . .	40	9
(6) Broach (1st generation) . .	17	0

Exotic cottons at Gadag. *New Orleans*, imported from the United States of America, in 1908, does not differ now from Dharwar-American. The seed, at first naked, is now fuzzy.

Allen's Long Staple is coming down to the local percentage and Boyd's Prolific has changed in the same way.

Texas Long Staple is maintaining its percentage better.

Texas Long Staple and Allen's Hybrid are the best of the exotics at Gadag. They ought to be put to the test on a larger scale, as soon as possible.

Dickson, Peerless and Cook are also to be tried on a larger scale next season.

In alternate lines of Dharwar-American and Cambodia evidence of inter-crossing is apparent to the extent of one per cent. The belief is gaining ground that Cambodia is more suitable than Dharwar-American for dry areas.

Dharwar-American. New Orleans type comes true. It is later in ripening than the true Upland form. The staple seems better than that of Upland although the latter was valued more highly in the market.

The Upland has a ginning percentage of about 30, the New Orleans 28.

The Upland type is being grown pure in the Ranebennur Taluka by Mr. Kottur. The two varieties are grown mixed in Gadag and Ron Talukas.

The following is a note on the auctions drawn up by Mr. Mankad :—

"The auction sale of Cambodia *kapas* was held at Gadag on the 9th May 1915. In all 20,000 lb. of Cambodia seed were reserved for distribution purposes, 3,000 lb. from the Gadag Farm and the remaining 17,000 lb. from the purified lot of the special class of the auction sale of last year. Of this quantity, about 7,500 lb. to cover about 400 acres were sown in the Gadag and the Ron Talukas. The same quantity was intended for the villages of the Bijapur District, but on account of the suggestion made by the Government to put out larger areas under cereals, only half the quantity was distributed chiefly in the village of Kundergi in the Bagalkot Taluka and the villages of Mangoli and Muttigi along the Don river where the conditions seem more favourable. The area under Cambodia cotton in the Bijapur District will be roughly 200 acres.

Sowing was done from the end of September till the first week of October. On the whole the season was not unfavourable to Cambodia cotton in the Gadag and the Ron Talukas of the Dharwar District but it proved very unfavourable to the Dharwar-American. In the Bijapur District, however, the crop suffered on account of abnormally heavy rains.

With regard to the sowing period, it seems that Cambodia in the District thrives much better when sown in the beginning of October. The experience gained on the

Gadag Farm shows that Cambodia gives better results when sown in the middle of September. The Divisional Inspector of Agriculture has taken up this matter of finding out the right season for sowing as a special study.

The District Agricultural Officers during their tour in connection with the inspection of the corp have found Cambodia thriving much better in the village of Sudi in the Ron Taluka and in the villages of Kurtkoti and Hulkoti of the Gadag Taluka than in other places. The soil and other conditions do not materially differ and the comparatively poor progress of the Cambodia cotton in other places requires careful investigation.

The outturn per acre varied from 400 ℔. to 100 ℔. *kapas* with a ginning percentage from 32·5 to 37. In some well-cultivated fields at Sudi the yield was 600 ℔. per acre, while the yield of Dharwar-American was not more than 500 ℔. in any fields. Experience shows that Cambodia thrives in years when the rainfall is moderate.

I am strongly inclined to believe after examining the cotton that the staple of the Cambodia cotton has not only become weak but has considerably deteriorated in length also, *i.e.*, the staple is both weak and short. Unless selection work is undertaken, I am afraid that this cotton will lose its reputation. Experienced cultivators say that the cotton bolls are now becoming smaller in size than they were when the cotton was first introduced.

The varying results of Cambodia cotton would always be a strong factor against the possibility of its extension in larger areas; the extension will also remain limited, as the Dharwar-American cotton is very promising in the Ranebennur Taluka and the adjacent parts.

All the *kapas* was not received at the auction depôt, as the needy cultivators cannot wait till the auction sale is arranged for.

In all 1,189 *dhokadas* (4 Dhokadas = 1 Naga = 1,344 ℔.) were received at the depôt. The cotton was graded in six classes according to the ginning percentages.

The prices offered for each class are given below per *naga* of 1,344 lb. :—

Class	Ginning percentage	Price
		Rs.
Special	37 and above	154
1st	36·5	145
2nd	35·5	146
3rd	34·5	140
4th	33·5	140
5th	32·5	135
Unclassified		132

The price of Dharwar-American on the day was Rs. 108. The prices realized are mostly from the point of ginning percentage.

It is proposed to purchase all the seed of the special class at 36 lb. a rupee, and about 1,000 lb. will be available from the Gadag Farm; so that the total quantity available for distribution this year will be about 10,000 lb.

With regard to the prospects of Cambodia and Broach cottons in the Southern Division, it can be said that :—

The two varieties of cottons have not been well established, as yet. In some favourable seasons they give excellent yields, while in some, they yield less than the local Kumpta. In some years there is timely rain for sowing the Broach variety early in July, while in others, the sowing season is unfavourable either through insufficient or too much rainfall. Similarly heavy late rains spoil Cambodia crop. Besides, there is a belief that the Broach crop impoverishes the soil and the following crop of *jowar* becomes very poor.

The percentage of lint also varies according to the nature of the soil though the seed sown is of very superior quality. Notwithstanding the above adverse conditions, people have a tendency to sow Broach cotton at least on a small scale and this tendency is due to the high price ensured to them by holding an auction sale by the Department.

The present high rate given by merchants in the auction sale is for the following reasons :—

(*a*) A large quantity of Broach and Cambodia *kapas* is gathered at one place by the efforts of the Department;

(*b*) The *kapas* is graded and there is a sort of guarantee for the declared percentage of lint;

(*c*) There is some Departmental check over the cultivators not to adulterate the cotton with other inferior varieties.

When the auction sale is stopped, merchants will not have the facilities mentioned above and the mill-owners will not be induced to buy the *kapas* at such high rates. The only merchants on whom the Broach and Cambodia cotton growers will have to depend, will be the local middle men, who, when they understand that there would be no auction sale, would offer as low a price as possible.

The only solution to continue the cultivation of Broach and Cambodia cottons in the absence of auction sales by the Department would be either :—

(*a*) that the cultivators should gin their own *kapas* and sell the lint, or

(*b*) that some organized bodies like the Agricultural Associations or Co-operative Societies should take up the work of arranging the auction sales on the same lines as is done at present by the Department.

The former appears to me to be impracticable. As regards the latter, it is a question whether the Agricultural Association, Dharwar, can undertake this sort of work independently.

I understand that the holding of auction sales has been financially successful to the Department. Besides, the work brings the Departmental Officers in close touch with numerous cultivators and cotton merchants. The expert merchants and mill-agents consider that the Broach cotton grown at Dharwar is as good a cotton as that grown at

Navasari or sometimes better. They have all along been giving good prices to encourage the cultivation and are still ready to continue the same. In the last auction sale Mr. Jijibhoy Ardeshiar Dewecha, Manager, Swadeshi Mills, Bombay, expressed his opinion that the cotton was very good and he would be glad to buy up to 10,000 bales of such cotton grown in the Southern Division.

In conclusion, it seems highly desirable that, until the cultivation of these two cottons becomes permanent on an extended scale, the auction of these should be continued by the Department. Similarly the steady supply of good seed (a large quantity from Navasari) will also have to be undertaken annually by the Department."

Messrs. Tata have the following valuations and remarks on six samples of cotton from the Gadag Farm :—

Serial No.	Name of Variety	Remarks
1	Dharwar-American—New Orleans type.	Both are far superior to Ordinary Saw-ginned Dharwar especially in length and strength of fibre. They have retained some characteristics of American. No. 2 is weaker in fibre than No. 1. No. 1 can spin up to 40's. Value Rs. 260. No. 2 can spin up to 30's. Value Rs. 245.
2	Dharwar-American—Upland type.	
3	Dharwar-American Ordinary.	It is ordinary saw-ginned. Can spin up to 20's Value Rs. 215.
4	Cambodia, saw-ginned	No. 4 is so nicely ginned that the staple does not seem to be cut as it ordinarily ought to appear. The length of staple almost equals that of No. 5, roller ginned. Can spin up to 32's. Value both Rs. 240.
5	Cambodia Double Roller-ginned.	
6	Christopher × Culpepper.	It is superior to Nos. 4 and 5 especially in strength of fibre. Can spin up to 40's. Value Rs. 260.

Bases of prices are the same as those given for the six samples of Dharwar above.

An analysis of the valuations and average outturn places the Gadag samples in the following order :—

	Per acre Rs.	A.
(1) Dharwar-American, New Orleans type .	33	4
(2) Christopher × Culpepper	31	9
(3) Dharwar-American, Ordinary . . .	29	2
(4) Dharwar-American, Upland type . .	22	6
(5) Cambodia, saw-ginned	19	8
(6) Cambodia, double roller ginned . .	19	8

Karkeli cotton. This was tested at Bhilvadi in the Tasgaon Taluka of the Satara District by the Inspector of Agriculture, Sholapur.

The outturn of seed cotton was 204 lb. The Inspector says that the outturn was poor owing to the want of rain at the time of sowing, and from heavy rain after sowing. The germination was hence not satisfactory. The ginning percentage was 30.

Messrs. Tata made the following remarks on a sample of this cotton :—" It seems to have deteriorated a little in length of staple. Can spin up to 32's. Value Rs. 210 (Karkeli of the day Rs. 215)."

An analysis of the outturn and value gives the crop a value of Rs. 16-5-0 per acre.

Cottons at the Agricultural College Farm, Poona. Three cotton varieties, Cambodia, Bhuri and Broach are being tested on this farm. The valuations of all are identical and Broach, although it yields the heaviest crop, is falling off in percentage.

Messrs. Tata report as follows on samples :—

1. Cambodia . . .	This cotton has somewhat deteriorated in length of staple. It is rather coarse in feel. In other respects it has retained its characteristics. Value Rs. 230 (Cambodia of the day at Rs. 240).
2. Bhuri . . .	Same as above but a little better in feel. Value Rs. 230.
3. Broach . . .	A little better than Fine Broach. Compared with Navasari grown in the District has deteriorated Value Rs. 230 (Fine Broach of the day Rs. 220).

The value of the crops stands as follows :—

	Per acre Rs.	A.
(1) Broach	60	6
(2) Bhuri	50	9
(3) Cambodia	46	15

Gujerat. The selected cottons are being grown by villagers round Surat on about 400 acres. There appears to be a consensus of opinion that the selected cottons are really superior to the prevailing article.

The Superintendent of the Surat Farm says that prices fluctuate in different centres of the District and cotton grown in the north invariably fetches a lower price than that in the south. Cultivators gain by taking the trouble to cart their cotton to the centre offering the highest price.

Ghogari exists as an appreciable mixture in Broach but not in Surat cotton.

The Superintendent also emphasized the fact which is true, *viz.*, that the Surat District is peculiar in that its conditions do not suit any outside variety of cotton so that cultivators would lose if adulteration of seed occurred. So far as we see then, Surat and Navasari cotton will always be grown pure and if contamination appears in the marketed product, it must take place after it leaves the cultivator's hands.

The Superintendent also assures me that the bulk of the Surat and Navasari cottons is bought forward by agents from the Ahmedabad Mills before the Bombay traders appear on the scene and that all the Broach cotton of the Bombay market is really grown in the Broach District. The prices offered by the Ahmedabad merchants are in advance of those offered from Bombay. It might be as well for the Department to bring its improved cottons to the direct notice of the Ahmedabad mill owners.

In *ghogari* the seed is larger than that of *deshi* and the cotton is more adherent so that it is more difficult to gin. The fuzz is white, while that of *deshi* is brown.

As a result of an inspection of many fields of cotton in the Jambusar Taluka of Broach we found that *ghogari* was grown in a very pure state. The prevailing form is round bolled and only a few plants with pointed bolls were found. In the event of a seed farm being established here to improve *ghogari* cotton, distribution could be easily arranged, as the villagers would naturally accept seed which is even only a little better than their own. There is sufficient land in the close vicinity of Jambusar town alone to provide area for seed farm purposes.

In Vavli village the cultivators co-operate in having their cotton ginned under their own supervision so that they are certain of getting back their seed pure. The difference in yield of clean cotton in *ghogari* as against *Broach Deshi* is 14 per cent.

The point to be decided was whether the farm at Broach is suitable for the improvement work in *ghogari* or whether it could be done more efficiently at Jambusar. It is known that *ghogari* bolls open badly in the real black soil but on the Broach Farm, where the soil is intermediate in character, this drawback is not encountered. It is therefore quite practicable to effect the selection at Broach for the whole of the *ghogari* tract and villagers round Jambusar would, no doubt, willingly agree to grow pure *ghogari* for seed distribution.

There are four types of *ghogari* cotton to be tested :—

(1) The first and typical has a large, round boll, with a high percentage of lint, which clings tightly to the seed which has a white fuzz. This will probably be the form ultimately selected.

(2) The second is a large, pointed boll, and the lint does not cling so closely to the seed. The fibre is finer and the fuzz is *brown.*

(3) and (4) are small bolled equivalents of (1) and (2).

On account of its high ginning percentage, its proportion in *Broach Deshi* mixture is steadily increasing and it would be safe policy to see that the cultivators get a hold of the best *ghogari* that can be developed.

Surat. Of the four cottons sent for valuation from this centre, taking into consideration their outturns and ginning percentages, they stand in the following order :—

	Per acre Rs.	A.
(1) Selection II—General	58	12
(2) Selection I-A.	53	4
(3) 1027 A L F	50	6
(4) Surti Broach Local	46	11

These figures prove that any one of the three selections is considerably in advance of the ordinary local cotton (the last) and it would pay the cultivator to take them up.

Sisodra Plot. In the Sisodra plot two of the above named varieties again come in and the three stand in the following order :—

	Per acre Rs. A.
(1) 1027 A L F	36 11
(2) Selection I	30 5
(3) Local Sisodra	29 12

There must be some good reason for the discrepancy in the value of the cottons from this plot as compared with those from Surat. It is probable that the cotton from Billimora and Chikhli furnishes the best so called Navasari cotton and that the product from Navasari itself is not quite so good as this.

Broach Plot. We have already noticed that the prevailing form *ghogari* is round-bolled and that only a few plants have pointed bolls. It is interesting to find from the market valuations that the commoner form yields the better cotton.

Next season when we will have outturn results from the two types of *ghogari* we may be able to say definitely which is the more profitable to grow.

Nadiad Farm. The acreage value of the indigenous *lalio* is Rs. 85-9 against Rs. 77-12 in Cambodia. This goes to prove that in the long run the local cotton will pay the cultivator best.

Madras. Although not requested to do so, I have taken the liberty of obtaining the expert opinion of Messrs. Tata, of Bombay on the cottons grown in the Presidency, samples of which were supplied for museum purposes.

Four samples of *karanganni* were received from Koilpatti Agricultural Station, of which three were special strains. The price of Tinnevelly for the day being Rs. 235, the ordinary *karanganni* sample with the percentage of

cotton to seed of 24, was valued at Rs. 220; Company No. 1 with percentage 27, valued at Rs. 245; Company No. 2 with the percentage of 31, valued at Rs. 240; Company No. 3 with the percentage of 33, valued at Rs. 235 per candy of 784 lb. There has been an increase of 9 per cent. in the percentage and an increase of Rs. 25 in the price. If the acreage results had been supplied, we should have been in a position to give the actual value of the cotton produced per acre.

Pulichai cotton is so largely contaminated with Berar seed that it is valued at the same figure. Company No. 2 (*Karanganni*, special selection by Mr. Sampson from last year's crop) is valued at Rs. 248, Tinnevelly of the day standing at Rs. 235.

The Cambodia samples from Koilpatti and Coimbatore were valued a little below the price of good Cambodia in Bombay.

Samples of *uppam* from Koilpatti and Coimbatore are valued at Rs. 205, the ordinary market rate. Bourbon from Coimbatore is valued equal to Navasari cotton at Rs. 270 and *nadam* from Coimbatore stands equal to Westerns at Rs. 200.

With Westerns selling at Rs. 200 in Bombay, the sample from Hagari was valued at Rs. 215.

With Northerns standing at Rs. 210, white-seeded Northerns from Nandyal was valued at Rs. 230; black-seeded Northerns from the same place at Rs. 225.

Coconada standing at Rs. 210, Yerrapatti red was valued at Rs. 215 and Coconada red, Rs. 205 and white Coconada from Samalkota, at Rs. 215.

Messrs. Tata make the following valuations and remarks on these samples :—

Basis of prices per candy of 784 lb. on 11th August 1915 :—

Tinnevelly, Rs. 235 : Uppam, Rs. 205 : Westerns, Rs. 200 : Cambodia, Rs. 240 : Northerns, Rs. 210 : Navasari, Rs. 270 : Berar Jari (Akola), Rs. 200 : Coconada, Rs. 210.

Serial No.	Name of Variety	Remarks
1	Ordinary *Karangannni* .	Of these four samples, No. 2 is best, Nos. 3 and 4 are alike, but a little bit inferior to No. 2 in length of staple. No. 1 comes last, being short in staple. Nos. 2, 3, 4 can spin from 30's to 32's. No. 1 can spin up to 24's. Value No. 1, Rs. 220; No. 2, Rs. 245; No. 3, Rs. 240; No. 4, Rs. 235.
2	*Karangannni* Special type Company No. I.	
3	Do. Company No. II.	
4	Do. Company No. III	
5	*Pulichai cotton* . .	This resembles Akola cotton. It is a short staple cotton. Can spin up to 16's. Value Rs. 200.
6	Tinnevelly cotton .	It is a strong, silky, good staple cotton more or less equal to Nos. 3 and 4. Can spin up to 30's. It is not *Uppam* as it is supposed to be. Value Rs. 235.
7	*Company No. 2*—Special Selection.	This is more like No. 2 but more silky. Can spin up to 32's. Value Rs. 248.
8	Cambodia from Koilpatti.	No. 9 is a bit longer in staple than No. 8. Both are silky, long stapled cotton. The fibre is weak and therefore cannot spin more than 32's. Value Rs. 235 for each.
9	Cambodia from Coimbatore.	
10	*Uppam* from Koilpatti	Both are alike coarse, short stapled, No. 11 being a bit whiter in colour than No. 10. Value Rs. 205 for each. Can spin 12's to 14's.
11	*Uppam* from Coimbatore.	
12	Bourbon from Coimbatore.	It is a long stapled, silky cotton. Can spin up to 40's. Value Rs. 270.
13	*Nadam* from Coimbatore.	It is very variable in length of staple and may be valued at Rs. 200. Can spin up to 16's.
14	White-seeded Northerns from Nandyal.	Both are silky long stapled cotton and strong fibred. No. 14 being whiter than No. 15, which is Red, No. 14 may be valued at Rs. 230 and No. 15, Rs. 225. Can spin up to 32's.
15	Black do. do.	
16	Yerrapatti Red . .	This is softer in feel and a bit longer in staple than Red Coconada. More suitable for dyeing. Value Rs. 215. Can spin up to 20's.
17	Coconada Red . .	Both are red and white ordinary types of Coconada. The fibre is coarse and staple shorter than No. 16. Can spin up to 16's. Value No. 17 (Red), Rs. 205. Value No. 18, for its colour Rs. 215.
18	Coconada white from Samalkota.	
19	Westerns from Hagari .	For Westerns, the staple is very good, being very long. Can spin 24's. Value Rs. 215.

N.B.—All the counts given here apply to warp and not weft.

It will be seen that in the majority of instances, a distinct advance in the value of cotton has been gained by

selection and if only ginning percentages and acreage outturns had been available, a rigid estimate could have been framed of the actual value of all the cottons which have been examined.

Burma. Mr. McKerral reports as follows :—

"The cottons received from you were grown at the Agricultural Station at Tatkon, Yamethin District, Burma. The year was rather wet and the cotton crop in general on this farm was not very successful. None of the Indian short-lived cottons were a success and they did not appear to do as well as the Burmese 'Wa-gale' (*G. neglectum*), which was grown alongside of them. The same was true of the long-lived types and Broach cotton proved a complete failure, while Burmese 'Wa-gyi' (*G. obtusifolium*) gave a fairly good crop although it flowered late. I conclude that our best chances of improving cotton in Burma will be to undertake selection for yield and ginning percentage with the indigenous varieties. I have, however, retained small cultures of all the cottons sent by you.

"With regard to the Burmese cottons, it was found that 'Wa-gale' (*G. neglectum*) which is our short-lived kind, consists of three well-marked botanical types (1) a yellow-flowered type, (2) a white-flowered. This occurs in small proportion in the ordinary crop and appears to be the type called by you 'Avena,' (3) a type showing reddish coloration of the petioles, leaves, bracteoles, etc., and possessing a longer and finer staple than the other types. This was found in samples received from the Shan States and looked a promising type. Unfortunately, however, its ginning percentage has been found to be very small. The white-flowered type appears to have the highest ginning percentage and in

the case of one single plant this appeared to reach 40 per cent. The white-flowered variety is being separated from the yellow and a large number of single plant selections of all three kinds have been made. No markedly different types have been observed so far in 'Wa-gyi' (the long-lived Burma cotton) and the crop appears to be fairly uniform. Further observations, however, are being made this year."

As in former years, I have to thank Messrs. Tata, Sons & Co., for the trouble they have taken in furnishing valuations of the numerous samples of cotton submitted to them.

III. Programme of work for the year 1915-16.

(1) To visit and advise on points regarding cotton and its cultivation whenever requested to do so by the Provincial Departments of Agriculture.

(2) The study of the behaviour of Bourbon, Bhuri, Cambodia and other such cottons in non-cotton-producing tracts, as detailed in the last year's programme, will be continued.

(3) An enquiry on the manurial requirements of cotton will be continued.

(4) Researches on the botany of cotton will be continued.

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REPORT

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1915-16

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1915-16.

REPORT OF THE DIRECTOR.

(J. Mackenna, M.A., I.C.S.)

I. Charge and Staff.

Charge. I succeeded Mr. B. Coventry, C.I.E., as Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, on the 1st April 1916, when he retired from the service of Government. Mr. Coventry has been identified with the Institute since its foundation and has been responsible for its development and growth. It is now one of the best equipped establishments of the kind in the East. Mr. Wynne Sayer was Assistant to the Agricultural Adviser throughout the year.

Staff. The following changes in staff took place during the year.

Mr. J. W. Leather, V.D., F.I.C., Imperial Agricultural Chemist, proceeded on combined leave from 16th September 1915, preparatory to retirement. He has since joined a Garrison Battalion of the Cheshire Regiment as a Major. Mr. Jatindra Nath Sen, M.A., F.C.S., Supernumerary Agricultural Chemist, was appointed to act as Imperial Agricultural Chemist.

Mr. A. Howard, C.I.E., M.A., and Mrs. Gabrielle L. C. Howard, M.A., the Imperial Economic Botanists, took one month's privilege leave from 10th November 1915.

Mr. E. J. Butler, M.B., Imperial Mycologist, returned from leave on the 16th November 1915, and resumed charge of the section from Mr. F. J. F. Shaw, B.Sc., A.R.C.S., who had been officiating.

Mr. T. Bainbrigge Fletcher, F.L.S., F.E.S., F.Z.S., Imperial Entomologist, held charge also of the duties of the Imperial Pathological Entomologist from the 9th August 1915, in place of Mr. F. M. Howlett, B.A., F.E.S., Imperial Pathological Entomologist, on leave.

Mr. C. M. Hutchinson, B.A., Imperial Agricultural Bacteriologist, was on privilege leave for one month from 7th September 1915.

The Agricultural Section was in charge of Mr. S. Milligan, M.A., B.Sc., up to 2nd June 1916, when he was transferred to Bengal as Officiating Director of Agriculture and Mr. G. S. Henderson, N.D.A., N.D.D., was appointed to officiate as Imperial Agriculturist.

Mr. W. A. Davis, B.Sc., A.C.G.I., F.C.S., was appointed to the special post of Indigo Research Chemist, and posted to Pusa. He joined his appointment on the 20th May 1916.

II. Work of the Institute.

Scientific work. The scientific work of the Institute during the year is indicated in the reports of the various sections.

Training. The training of students in post-graduate courses was continued and short courses were also given in cattle management and sericulture.

In the section of Agricultural Bacteriology two students completed their course during the year under report and returned to their respective Provinces. An Assistant deputed by the Assam Department of Agriculture is now under training.

In the Botanical Section an Assistant deputed by the Burma Department of Agriculture was trained during the year in work connected with wheat-growing.

In General Entomology two students completed their training and at the end of the year under report one agricultural graduate is taking this course.

In the Mycological Section, two students completed their course during the year.

An Assistant deputed by the United Provinces Department of Agriculture is undergoing training in general agriculture in the Agricultural Section.

Besides the regular students referred to above the following visitors also worked in the laboratories :—

Mr. Karm Chand Mehta, M.Sc., Professor of Botany, Agra College, and Mr. Bamanji Nowroji Vakil, B.Sc., of Bombay, worked in the Mycological Laboratory from 3rd March to 27th March 1916, and 15th March to 25th April 1916, respectively. Mr. Mahdi Hasan, a private student from Hyderabad, Deccan, worked in the Entomological Laboratory for about four months. Mr. Deoki Nandan, M.R.A.C., took a course in general agriculture, mycology and entomology.

Three students took the short course in sericulture and a graduate of the Lyallpur Agricultural College took the special course in cattle breeding and dairying.

III. Publications.

The Agricultural Journal of India, Scientific Memoirs and Bulletins continued to be issued during the year. The Department published during the year 13 Memoirs and 6 Bulletins; 6 Memoirs and 4 Bulletins are in the press. The Proceedings of the Inter-Provincial Jute Conference (1915) and of the 9th Meeting of the Board of Agriculture in India (1916), were also issued during the year. A Bengali version of Bulletin No. 48, has been published and copies

distributed free in the important silk centres of Bengal. A revised edition of the Manual of More Deadly Forms of Cattle Disease in India was also published during the year. A special number of the Agricultural Journal of India was issued including all papers of agricultural interest read at the Third Indian Science Congress held at Lucknow in January 1916. A revised edition of Bulletin No. 39 and the second edition of Bulletins Nos. 52 and 53, are in the press. The grant of Rs. 29,000 permanently sanctioned for publications was continued during the year under report. Owing to the continued rise in the prices of paper and other materials, strictest economy had to be exercised to keep down the expenditure within the sanctioned limits.

IV. General Administration.

Buildings and Works. During the year under report four additional quarters for the subordinate staff were completed and four more quarters are under construction. The female ward for the Pusa Hospital was also completed during the year. Necessary funds have been allotted for the installation of electric lights and fans in the European bungalows and the work is in the hands of the Public Works Department. The new ice machine referred to in last year's report has been installed. Several minor works were also done during the year out of the grant of Rs. 5,000 placed at my disposal in the civil works budget of the Public Works Department.

Library. The third edition of the catalogue of the Pusa Library, was issued during the year. In addition to the foreign bulletins, memoirs, reports, etc., which are received in exchange from different parts of the world, over 300 volumes were purchased for the library during the year.

Pusa Schools. The number of pupils attending the Pusa High School at the close of the year was 185. In March 1916, the school sent up seven boys for the Matriculation Examination of the Calcutta University and of

these five passed in the first division and one in the second division.

The Lower Primary Girls' School remained closed during the greater part of the year on account of the death of the mistress of the school. It is hoped that the vacancy will soon be filled as there is a demand for female education

General Health of the Station. The general health of the station during the year under report was satisfactory. Relief was afforded to 10,458 persons at the Pusa Hospital, of which 10,223 were treated in the out-patients department and 235 in the indoor department.

The average daily attendance was 68·07 in the out-door and 12·01 in the indoor departments.

The total number of deaths in the hospital were 11. Most of these cases were brought to the hospital in rather advanced stages of illness.

Occasional outbreaks of cholera in the villages lying in the immediate vicinity of Pusa during the months of September, November and December 1915, became a source of great danger to the Estate. Preventive measures were promptly taken, and the wells were thoroughly disinfected with the result that the disease did not enter the Estate.

Thirty-two primary and eight re-vaccinations were done during the year.

V. Accounts.

The total expenditure during the financial year 1915-16 was Rs. 4,63,817, as under :—

	Rs.
Office of the Agricultural Adviser to the Government of India and Director of the Institute	2,00,852
Chemical Section	31,699
Mycological Section	32,231
Entomological Section	41,297
Pathological Entomological Section	16,728
Botanical Section	43,803
Bacteriological Section	28,436
Agricultural Section	68,771
Total	4,63,817

In addition to the above a sum of Rs. 23,502 was spent out of the provision of Rs. 23,560 made under "Sugar Experiments" in the budget of this Department for 1915-16, in connection with the engagement of Mr. W. Hulme as Sugar Engineer in the United Provinces.

A sum of Rs. 15,000 was paid as a grant-in-aid to the Indian Tea Association.

The principal items of expenditure under the annual grant of Rs. 10,000 placed at the disposal of the Agricultural Adviser to the Government of India for special Agricultural Experiments were as follows:—

	Rs.
Purchase of a small sugarcane crushing plant required for experiment by the Agricultural Chemist, United Provinces . .	500
Cost of additional machinery for sugar plant required by Mr. Hulme	6,000
Purchase of silk yarn for sericulture experiments at Pusa	194
Experimental cotton cultivation conducted by the Imperial Cotton Specialist . .	1,500
Pay of a Veterinary Assistant in connection with cattle breeding and of a Fieldman for mosquito experiments	863

The gross receipts during the year from the sale of farm produce, milk, publications of this Department and other articles amounted to Rs. 15,340 as against Rs. 16,843, in the previous year.

VI. Conferences.

An informal conference on the subject of Agricultural Education was held at Pusa on the 4th and 5th February, 1916, under the presidency of the Hon'ble Mr. C. H. A. Hill, C.S.I., C.I.E., I.C.S. It was composed of officials of the Agricultural and Education Departments, Mr. Fremantle, Collector of Allahabad, one non-official member and myself. The ninth meeting of the Board of Agriculture in India was also held at Pusa in the same month. It was attended by 47 members and 24 visitors and was pre-

sided over by Mr. Coventry. The arrangements were made by Mr. Wynne Sayer, Assistant to the Agricultural Adviser to the Government of India, who also acted as Secretary to the Board.

VII. VISITORS.

His Honour the Lieutenant-Governor of Bihar and Orissa, visited the Institute on 6th August 1915. During the year under report the Hon'ble Mr. C. H. A. Hill, C.S.I., C.I.E., I.C.S., Member-in-Charge of the Department of Revenue and Agriculture, the Hon'ble Mr. R. A. Mant, I.C.S., Secretary to the Government of India, Department of Revenue and Agriculture, Mr. Van Geuns, Editor of the *Soerabajasch Handelsblad*, Java, and others visited the Institute.

REPORT OF THE IMPERIAL AGRICULTURIST.

(G. S. Henderson, N.D.A., N.D.D.)

I. Administration and Tours.

Mr. Milligan held charge of the post till the 2nd June 1916, and then handed over charge to me on his being appointed to the post of Director of Agriculture, Bengal.

The senior members of the staff remained practically unchanged. An appreciative note was left by Mr. Milligan of their services.

Mr. L. S. Joseph acted for Mr. Judah Hyam, Veterinary Overseer, for a month and then volunteered for military duty, on the transport of horses to Egypt, for two months. He again volunteered for military duty and went to Mesopotamia on the 6th July 1916.

Tours. Mr. Milligan examined students at the Cawnpore Agricultural College in September 1915, also visited Hoshangabad and Panna State in Central Provinces and the Kamrup sugarcane estate in Assam in January.

II. Training.

There were during the year under report three students, post-graduates, who got a practical insight into the working of the farm and the details of steam cultivation.

III. Farm Cultivation.

The rainfall was 51·37 inches as compared with 54·88″ last season. Heavy rains fell in August and the new 18″ drainage pump was working during most of the month. It cleared the stagnant water in a satisfactory fashion. The October rains were poor.

Cropping. The major portion of the farm is cropped for the purpose of feeding the breeding herd, work cattle, etc. The stock at Pusa averages about 430 head, this requires an enormous amount of stuff. In one day 100 maunds of green fodder, 25 maunds of oat straw and 17

maunds of grain are supplied. When the seasons for green fodder and silage are finished, over two tons per day of oat straw are needed. Fifteen thousand maunds of silage were used during the year.

In the past season there were 280 acres of land double cropped, mostly maize in kharif, sown with *arhar* (*Cajanus indicus*) reaped in rabi, or maize followed by oats in rabi. 147 acres were single cropped. The area of crops was over 700 acres. Fallows were 120 acres.

In addition to the oats, maize and *arhar* supplied as concentrated food, seed has to be kept for the next season. The budget, buildings and equipment are all insufficient for the area cultivated. Bamboo *kutcha* sheds have to take the place of more permanent structures. The roofs of the breeding herd buildings, a part of the old horse breeding establishment, are in a precarious condition. A mile or two of light tramway would facilitate the working of the estate.

The set of steam tackle (Fowler's double engine, K. class, single cylinder) worked 254 days and the following work was done :—

Ploughing with disc plough	260	acres.
Disc harrow	1,549	,,
Grubber	735	,,
Roller	529	,,
Zig-zag harrow	195	,,

The best work in one day for each operation was 7 acres ploughed, 22 acres harrowed, 18 acres grubbed, and 27 acres rolled.

All crops were drilled and then from time to time intercultured with Wallace's horse hoe and hand weeding was reduced to a minimum.

Crop Experiments. About 20 acres of sugarcane were grown without any irrigation; 6,639 maunds of cane were sold to a factory.

The series of permanent rotational and cropping experiments were continued.

A series of green manurial experiments in conjunction with the Imperial Agricultural Bacteriologist was continued.

The new experiment field is being tested uniformly with oats in order to select plots of similar output.

The *rabi* crop of oats all over the farm was exceptionally good. In the weighed plots the best yields were, wheat 30 maunds per acre, oats 39 maunds per acre and barley 24 maunds; the total yields of grain exceeded the last year's yield by over 1,600 maunds.

IV. Live-Stock.

Cattle Breeding. Two herds are being kept at Pusa, one of selected Sanhiwal (Montgomery) cows and their descendants and the other of cross-bred Ayrshire-Sanhiwal cattle. From want of ground and buildings, however, both herds are kept together. There are 7 bulls, 2 Ayrshire bulls (Carston Royal Scotch and Lessnessock Wildfire), 107 cows, 59 bull calves, 103 cow calves and 25 young cross-bred stock.

In the pure bred herd 4,000 lb. of milk in a lactation period has been accepted as the standard, anything less will fail to qualify for admission. The herd is kept in 5 groups with a separate bull for each group, this will enable the herd to be carried on for a considerable time without outside blood.

Among the cross-breds the heifers produced by the first Ayrshire bull "Mossgeil Titanic" (now dead) will be crossed by the produce of "Lessnessock Wildfire."

During the year there were on a daily average 119 customers for milk, the average number of cows in milk was 55, and the average daily yield of milk was 35 gallons including the milk taken by the calves.

Two cows, Mookhia and Roopiria, each produced over 490 gallons.

Nine animals were sold from the herd for breeding purposes at nominal rates to approved breeders.

Sheep Breeding. Operations have been continued as described in last year's report. The sheep now number 211 head.

V. General.

Drainage. The new bund round the south of the estate was completed and a number of drains in the Brick-field and other low places were dug. The drainage system is very complete now and with the exception of two fields which are outside the scheme any ordinary flooding can be dealt with expeditiously.

Levelling. Some levelling was done with bullock scrapers but nearly all fields still require some low places filled up.

A new 4 feet 6 inches threshing machine was used for threshing the oats, etc. The best day's work was just under 400 maunds of cleaned oats.

VI. Programme of work for 1916-17.

The following are the lines of work in progress :—

Major investigations.

1. Economics of cultivation of steam engines.
2. Investigation of most suitable rotation and manuring for land devoted to cattle feeding.
3. Trials of various leguminous fodder crops.
4. Study of inheritance of characters of dairy cattle by crossing.
5. Building up of milk pedigree in cattle by selection.
6. Manurial experiments with fermented green manures in collaboration with the Imperial Agricultural Bacteriologist.

Minor investigations.

7. Inheritance of wool characters in sheep.
8. Experimental tillage in growing of maize and sugarcane.
9. Improvement of pastures.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(J. SEN, M.A., F.C.S.)

I. ADMINISTRATION AND TOURS.

Charge. The section was in charge of Mr. (now Major) J. W. Leather, V.D., F.I.C., up to the 15th September 1915 when he proceeded on long leave preparatory to retirement. He has since joined the 3rd Battalion, Cheshire Regiment. The First Assistant was in charge of the current duties from 16th September to 6th November 1915 when I took over charge of the section as Officiating Imperial Agricultural Chemist.

Establishment. Mr. P. N. Mehta, B.A., was appointed an assistant on 10th July 1915.

Mr. B. M. Amin, the Third Assistant, has been deputed to work under the Indigo Research Chemist with effect from the 15th June 1916.

Babu Upendra Nath Sen Gupta, B.A., was appointed a probationary assistant from the 15th June 1916.

Tours. Major Leather visited Simla in July to confer with the Commissioner of Northern India Salt Revenue about the experiments on refining saltpetre and also went to Cawnpore in September to arrange about draingauge work.

I went to Sabour in December to see to the harvesting of my experimental plot of paddy there.

II. EDUCATION.

Babu Upendra Nath Sen Gupta joined this section as a private student but has afterwards taken up appointment as an assistant.

III. METEOROLOGY AND DRAINGAUGES.

In addition to the usual records for the Meteorological Department, records of atmospheric pressure by means of a

barograph have been maintained. Work in connection with draingauges here is being kept up. The waters and crops from the Cawnpore draingauges are also being analysed as usual.

IV. Infertility under trees.

The problem of the occurrence of infertile patches in the soils under trees is being studied. It has been found that in many cases, though not in all, this is associated with a decreased permeability of the soils and the presence of soluble salts.

V. Rice.

The Rices of Bihar and Orissa. In view of the importance of a chemical study of this valuable food crop the examination of the composition of the rices grown in Bihar and Orissa was undertaken, along with other related questions of interest.

It was thought desirable to confine the work to samples of rice in the Government farms, where they are grown under definite cultural conditions. The rices were, however, not pure line cultures. Of the samples received, three came from Bankipore, one from Bettiah, three from Cuttack, thirteen from Dumraon and five from Sabour. The samples studied did not include any *boro* rice.

Composition of the Rices. The composition of the rices did not vary much.

The analytical figures allow an interesting deduction. The amounts of oil, fibre and ash vary between very narrow limits and the sum of these constituents will be more or less constant. The sum total of the remaining constituents of albuminoids and soluble carbohydrates is thus also constant. It was found that the sum of the percentage figures for albuminoids and soluble carbohydrates, in all instances except three, fell between 94 and 95. In these three latter cases the figures were 93·9 and 95·3. But the deviation is so small that the general observation may be said to hold good in these instances also. It was thus noted that when

the amount of albuminoids was high the carbohydrate content was low and *vice versâ*.

The amount of phosphoric acid is always very slightly less than half of the total mineral matter present. Potash is, again, very nearly half of the amount of phosphoric acid present.

The effect of polishing. The composition of polished rice is dependent somewhat on that of the original unhusked rice. But although the amount of substance removed as bran is not very much, the grain suffers a material alteration in composition. The polished rice becomes poorer in all constituents except soluble carbohydrates which increase a little. The amount of oil decreases to less than half; the albuminoids suffer only a slight diminution; the fibre is reduced to about one-fourth of the original quantity and the amount of mineral constituents falls to a half. The outer layer and the embryo which are removed during the polishing operation are thus seen to be richer than the inner material in all these constituents. But the concentrations of fibre and oil in the bran are relatively higher than that of the mineral constituents. The distribution of the albuminoids is more uniform than that of any of the above.

It has been noted already that in the unpolished grain the quantity of phosphoric acid is just less than half of the ash. In the polished rice also, the phosphoric acid is slightly less than half of the amount of ash. The potash content, however, which in the unpolished rice is about half of that of the phosphoric acid now rises to about three-fourth of the amount of phosphoric acid.

It thus amounts to this that, although both phosphoric acid and potash are more concentrated in the " bran " than in the rest of the seed, the distribution of the potash is more uniform than that of the phosphoric acid.

As regards the material lost during the operation of polishing, this consists of the plant embryo and some of the outer layers of the grain. The germ being freely exposed and not embedded in the grain is easily rubbed off, the little

nick at one end of the polished grain marking the place where it was located.

Rice as an article of diet. It might be supposed that the estimation in which any variety of rice is held among the consumers, as evidenced by its market price, would be mainly determined by its nutritive value and its palatibility. The latter term includes culinary properties, such as flavour, consistence. appearance, taste, etc., which cannot be definitely described and are rather difficult to observe accurately.

As regards the nutritive value of rice, as revealed by analysis, there is no doubt that, other things being equal, the variety of rice which contains larger amounts of albuminoids is more valuable, inasmuch as albuminoids, which are the flesh formers, are a more expensive form of food than starch. The relative nutritive value of a sample of rice can thus be assumed to depend on its albuminoid content. It was noticed, however, that no accurate relation can be found between the chemical composition and the value of a rice from the consumer's point of view.

In a well-balanced ration, the relations between the albuminoids, the oil and the soluble carbohydrates should vary within certain definite limits. Rice, however, in common with other cereals, contains an excessive proportion of starch and is thus not suitable for use as the sole article of diet by any one.

This holds not only from the point of view of the organic constituents but also of the mineral ones, which are the bone-formers. Rice is quite poor in this respect also. The importance of giving due consideration to the amount and composition of the ash of foods is very great in order to ensure the supply of material for the proper development of bone, and of the mineral constituents necessary for vital processes—factors which have as much influence on the well-being of animals as proteids, carbohydrates and fats in appropriate quantities.

Where a variety of food stuff is used, the probability of much injury being done by ignoring these aspects of the

question is not very great. Happily the use of rice is nearly always supplemented by the addition of other substances of vegetable and animal origin which often supply the deficient elements.

An interesting characteristic of rice protein may be mentioned here. It has recently been shown that in its general aminoacid make-up the protein of rice more nearly resembles the majority of the proteins of animal tissues than do the proteins of maize and wheat. This may explain the fact that rice, in spite of its low protein content, furnishes food for more human beings than any other cereal.

The alteration in composition which rice undergoes during the process of polishing is of great significance from the medical point of view. Some authorities believe that beri-beri is due to specific germs. Others think that it is caused by the bacterial fermentation of the large amounts of carbohydrates eaten in unbalanced diet. But the consensus of opinion is that beri-beri is one of the " deficiency diseases " like, *e.g.*, scurvy or rickets. Most of the food articles in their raw state contain the curative substances. These are, however, at times lost, or considerably reduced, during the process of " finishing " and preparation which the fastidious taste of the modern consumer prescribes. Reduction in the content of phosphoric acid is now generally accepted as an index of the beri-beri-producing power of a sample of rice. Judged by this standard, although all samples of unhusked rice used during this investigation were good, many samples of the " polished " rice were unfit for consumption as a sole article of diet. It must be remembered, however, that rice is almost universally supplemented by some other foodstuffs, the mixed diet often to a great extent nullifying much of the apprehended injurious effects.

Assimilation of nutrients by the plant. The proper supply of nutritive elements is an important factor in the growth of a plant and, in view of the economic importance of the rice crop, a study was made of the assimilation of the nutrient materials by this plant at various stages of its growth.

For conducting these experiments a uniform plot of rice land was chosen at the Sabour Farm. The seed employed was "kalamdan" which is at present the standard medium aman paddy of the Sabour Farm. It was originally derived from pure culture and its purity was maintained, as far as is possible under field conditions, by rogueing every year.

In order to do away with the disturbing factors consequent on transplanting, it was decided to allow the rice to grow to maturity in the same field where it was sown. After the usual cultivations, the seeds were sown in the third week of May, by dibbling in plough furrows and afterwards covering them up by beaming. Weeding was done when required. The plot had to be irrigated once in August.

Samples of plants (the exact number of plants varying according to the size) were selected in such a way as to fairly represent the whole crop. It was not possible to take out the whole root system but care was taken not to lose much of the roots. After the soil adhering to the roots had been washed out the plants were divided into their botanical parts and analysed. The following samples were taken :—(1) very young seedlings, (2) at the transplantation stage, (3) at preflowering stage, (4) at the flowering stage (two samples, one in which the grain was in the "water" stage, and another in which it was beginning to form "milk"), (5) at the ripe or ordinary harvest stage and (6) when the crop was dead ripe. The results obtained need not be entered here in detail but some of the points observed may be mentioned.

1. The total dry matter in a rice plant increases up to the time of maturity, the largest increase in the weight of the crop occurring before the formation of the flowers.

2. The percentage of nitrogen generally exhibits a steady and continuous decrease from the first to the last period of growth, the most rapid decline being noted in the second period. The above-ground parts are always richer than the roots in their nitrogen content. At the ear-

lier stages the leaves are practically twice as rich in this element as the stems. As the ears form, both the stems and the leaves lose nitrogen. By the time that the grains "fill up" the nitrogen accumulates most in the grain while in the other parts of the plant it falls to the uniform level of about a third of what is present in the grains. It seems therefore that there is a tendency for the nitrogenous matter to press forward towards the top of the plant.

3. The configuration of the curve of the content of phosphoric acid at the different stages indicates that the amount of this plant food available for the rice plant at Sabour was low throughout.

4. The percentage of potash in the above-ground parts increases from the first stage to the preflowering stage from whenceforward there is a decline. In the roots also there is a continued fall after the second stage.

5. As the ears form and mature there occurs a concentration of nitrogen, phosphoric acid and potash in the grains at the expense of the other parts of the plant.

6. The assimilation of nitrogen, phosphoric acid and potash by the plant is fairly complete by the time flowers appear. Hence enough plant foods must be available for the plant during the early stages.

7. There does not seem to be any migration of the absorbed nitrogen and potash back into the soil.

8. Taking the yield of a crop of rice as 900 lb. of dry grain, the soil suffers a depletion of 29·33 lb. nitrogen, 9·64 lb. phosphoric acid and 49·69 lb. potash per acre by the removal of the grains and straw.

Feeding value of the different parts. As to the feeding values of the different parts of the rice plant, as calculated from the chemical analysis at the various stages, it was found that the straw declines in value with the age of the plant but there is no difference in nutritive value between ripe and dead ripe plants. The leaves are more nutritious than the stems of the same period. The leaves in the preflowering and the flowering stages are about

equally nutritious but decline considerably in value as the plant matures.

VI. Feeding Stuffs (General).

A considerable number of samples of feeding stuffs have been analysed, the greatest number being, as in last year, from the Military Department. It is intended to issue a bulletin incorporating the results of these and other analyses.

VII. Starch.

The experiments begun last year in connection with sweet potato as a possible source for the commercial production of starch, have been continued.

In order to find out the yield and quality of starch at different periods of growth, fortnightly harvests were made from a field of sweet potatoes, from the latter half of January to the end of March. The analysis showed that the best time for harvesting the crop was the middle of February.

Through the kindness of the Imperial Agriculturist arrangements are being made to grow different varieties of sweet potato in a plot of land better suited to this crop.

Another crop tested was the kidney-shaped yam, *Dioscorea fasciculata* (vern. *suthni*) which also is largely grown here. One sample was found to contain 19 per cent. of starch, and to yield a very good quality of starch.

VIII. Lathyrus sativus.

An attempt was made to find out the poisonous constituent of *Lathyrus sativus* (vern. *khesari*) which has a bad reputation for causing paralysis. Samples of this pulse grown at Pusa and at Barail (a village 8 miles from Pusa which is notorious for cases of lathyrism) as well as some samples from the Central Provinces (where also bad cases of the disease occur) were examined. No alkaloids were detected although some of the previous workers had found what seemed to be a volatile alkaloid.

During the course of this work it was found that *khesari* samples are very often contaminated with foreign seeds from which a cyanogenetic glucoside was isolated and some feeding experiments were conducted with guinea pigs. These seeds were identified as *Vicia sativa* (vern. *akta*) and *Vicia hirsuta* (vern. *misia*). As the chemistry of these grains had been worked out by Ritthausen, further investigation was abandoned.

IX. Relation of Transpiration Ratio and absorption of food materials.

Pot culture experiments were started during the year to ascertain the relation between the transpiration of water and the assimilation of plant food at different stages of the plant's growth. The following crops were sown :—Maize, velvet bean, *rahar* and *marua* in the *kharif* and *sarson*, wheat and gram in the *rabi*.

The soil employed was Pusa soil and received an application of superphosphate and potassium nitrate. The moisture content of the soil was maintained at 20 per cent. and the transpiration was daily measured. At regular intervals the plants from the jars were harvested and analysed for nitrogen, phosphoric acid and potash.

Some interesting results have been obtained but results of further experiments are awaited before definite conclusions could be justified.

X. Programme of work for 1916-17.

Major subjects :—

1. Records of the amount and nature of drainage water from fallow land, and land bearing crops, will be maintained.

2. The relation between the transpiration of water by plant and the assimilation of plant material during the period of growth will be further studied.

3. An examination of the proportion of starch in some of the Indian starch-producing crops will be made with a

view to their possible utility as commercial sources for the manufacture of starch.

Minor subjects :—

1. The assimilation of plant material by the rice plant will be further studied.

2. The problem of the occurrence of infertility under trees will be examined.

XI. Publications.

The following papers were published during the year :—

(1)	Leather, J. W. .	Soil Temperatures. *Mem. Dept. of Agri., India* (*Chemical Series*), Vol. IV, No. 2.
(2)	Leather, J. W. .	Soil Gases. *Mem. Dept. of Agri., India* (*Chemical Series*), Vol. IV, No. 3.
(3)	Leather, J. W. .	The Detection of Added Water in Milk in India. *Bulletin 57, Agricultural Research Institute, Pusa.*
(4)	Sen, J. . .	A Preliminary Chemical Study of the Rices of Bihar and Orissa. *Bulletin 62, Agricultural Research Institute, Pusa.*
(5)	Sen, J. . .	A study in the assimilation of nutrients by the rice plant. *Bulletin 65 of the Agricultural Research Institute, Pusa.*

REPORT OF THE IMPERIAL ECONOMIC BOTANISTS.

(A. Howard, C.I.E., M.A., and Gabrielle L. C. Howard, M.A.)

I. Introduction.

The Imperial Economic Botanist held charge of the section during the year with the exception of one month (November 10th—December 9th, 1915), when privilege leave was taken in India. The Second Assistant was in charge of current duties at Pusa during this period and the Third Assistant was placed in similar charge at Quetta. Both of these assistants acted up to the level of their responsibilities.

The work of the staff during the year was quite satisfactory. Babu Kashi Ram was appointed to the post of Fourth Assistant on transfer from the Saharanpur Botanical Gardens and has made a good beginning in his work. This opportunity is taken of acknowledging the valuable assistance given by Mr. Hartless, the Superintendent of the Saharanpur Gardens, in training men for work in the Botanical Section at Pusa and also at the Fruit Experiment Station at Quetta. Babu Chandu Lall has improved in his work at Quetta and has been confirmed and promoted by the Baluchistan Administration.

One student from Burma worked in the section during the cold weather.

Mr. Jatindra Nath Sen, officiating Imperial Agricultural Chemist, has carried out a good many analyses for the section which have proved of considerable use in our investigations.

II. Investigations at Pusa.

Wheat.

Pusa 12. While a beginning has been made in several Provinces in distributing this wheat to cultivators, these efforts are of minor importance compared with the schemes

in progress in the United Provinces where the Agricultural Department, during the past year, has made considerable progress in the systematic replacement of the country wheats by this improved type. The trial of Pusa 12 in these Provinces has passed the experimental stage and the time is rapidly approaching when it will be possible to see large continuous blocks of this variety true to type. At first, progress was greatly hampered by a shortage of seed but with an increasing supply and with larger funds for financing the operations, these preliminary difficulties are being overcome. A feature of the work of seed distribution in the United Provinces is the manner in which all the existing agencies have been utilized. In the Central Circle, the Co-operative movement has largely been employed in addition to Court of Wards' estates and large zamindars. In Oudh, an entirely new agency has been brought into use by Mr. Sharma, namely, the local notables, who, in a sense, are large and wealthy Co-operative Societies ready-made commanding great influence with the cultivators. Anyone who has seen the work in progress with Pusa 12 on some of the large private estates in Oudh cannot fail to be impressed by the immense possibilities of this new departure. Improved agriculture on these estates has been found to be very profitable and the new private seed farms, such as those personally conducted by the Raja of Amethi and the Kunwar Sahib, are proving of great value to the Agricultural Department in the replacement of the local wheats by Pusa 12.

Like the season of 1913-14, the year in the United Provinces was characterized by a shortage of moisture, particularly in the Western Districts. Pusa 12 again withstood satisfactorily these adverse conditions and its behaviour, as compared with the country wheats, was summed up as follows by the Director of Agriculture in "United Provinces Agricultural Notes" for March and April 1916 :—

"Pusa 12 wheat has again proved markedly superior to the Provincial wheats, and is likely to go ahead rapidly over the western and central portions of the provinces.

Apart from its qualities of yield, it requires less water than the best local varieties, such as Muzaffarnagar, and is likely to take the place of the latter in the canal tracts owing to recurrent shortages of the water. In one of the private estates in Oudh in which there are 75 acres under this wheat, the crop, which is being threshed out by the Department, has given an average of 25 maunds of grain and 45 of *bhusa* per acre." (*Pioneer*, April 9th, 1916.)

" Figures have been received from Co-operative Societies as to the relative yield of Pusa 12 and *deshi* wheat. In two neighbouring societies, in the Central Circle, the average yield of Pusa 12 was 19 maunds per acre and of *deshi* $16\frac{1}{4}$ maunds. The former wheat stood the test of a dry season satisfactorily. Crop cutting experiments were carried out in fields where only one irrigation was possible; and the yield of Pusa wheat was 17 maunds as compared to $14\frac{1}{4}$ from *deshi*. On an average, the former wheat yielded substantially more *bhusa*." (*Pioneer*, April 8th, 1916.)

These results enable a rough estimate to be formed of the annual increase in value of the crop which will be obtained when the whole of the wheat-growing area of the United Provinces is replaced by Pusa 12 or some similar improved type. As far as yield of grain and *bhusa* are concerned, the increased production due to Pusa 12 comes to over twelve rupees an acre. If the improved grain quality is estimated at three annas a maund and if the average production is put at sixteen maunds to the acre, the increase in the value of the crop from this cause would be three rupees an acre. Considering that Pusa 12 already commands a premium of more than four annas a maund in the local bazaar, the above estimate is well within the truth. If, therefore, we take into consideration both yield and quality, the substitution of the country wheats by Pusa 12 means an immediate average increase of fifteen rupees an acre or £7,000,000 per annum for the whole of the United Provinces.

While the local transactions in Indian wheat are considerably more important than the export trade, neverthe-

less the latter is well worthy of consideration even under the present conditions of production. If, however, an increase in yield is brought about by changing the variety or by better methods of cultivation, the surplus left over for export will increase and India will then take a larger share in the wheat production of the Empire. There can be little doubt that such a result is easily possible. At present, the great plains of India do not produce half of what is possible. With a few simple improvements, the alluvial soils of India could be made to grow twice their present crops and the Punjab and the United Provinces would then become the most important bread-basket of the Empire. Wheat-growing is at present one of the great neglected and undeveloped natural industries of India. The capital for expansion is lying ready to hand in the shape of a marvellously fertile soil when properly managed, while in the cultivator and in his oxen is the foundation of the labour force necessary for development.

In consequence of the extension of indigo cultivation in Bihar, the area of Pusa 12 put down for seed on the estates was considerably restricted. In spite of the high prices of indigo, over 3,000 maunds of seed of this type were supplied to Mr. Burt for distribution in the United Provinces.

Pusa 4. The circumstances of soil and climate in some of the wheat-growing tracts of India are such that a rapidly maturing variety is one of the conditions of progress. In tracts like Bundelkhand, some of the Central India States, the southern portions of the Bombay Presidency and parts of Bihar, a wheat is required which can ripen quickly with a short supply of moisture and which can also resist the early rusts. In such tracts, deep-rooting, high-yielding kinds are useless and producing power has to give place to the insurance of the yield in years of average soil moisture. In such areas, Pusa 4 is giving good results and is being taken up by the cultivators. The demand for seed is increasing and for several years to come the surplus produce from the indigo estates in Bihar is likely to continue to find a ready market. Pusa 4 is a large-grained, attractive-looking wheat which at once finds favour with the cultiva-

tors and in the bazaar on account of its grain quality and the high percentage of flour it yields.

During the year, a complete milling and baking test of this variety was carried out at the Hooghly Flour Mills, Calcutta, managed by Messrs. Shaw, Wallace & Co. The sample milled was 350 maunds in weight and was grown as a cover crop for Java indigo on the Dholi and Benipore estates in Bihar. The report, which will be published in due course, is an exceedingly favourable one. The wheat behaved in the mill exactly as would be expected from Mr. Humphries' reports on maund samples in England while the loaves were much superior to those produced from the best Calcutta flour.

Pusa 4 is doing very well in New South Wales. A large sample, grown at Gilgandra from seed supplied from Pusa, took the first prize at the recent Royal Agricultural Show at Sydney. This prize has formerly been obtained by one or other of the wheats produced by the late Mr. William Farrer. Both in appearance, bushel weight and in the milling tests, Pusa 4 proved superior to any of the new varieties produced in New South Wales.

The demand for seed of Pusa 4 increased considerably during the past year. In addition to numerous small consignments, about 1,500 maunds were supplied from Bihar estates to Mr. Burt, in connection with his seed distribution scheme in Bundelkhand. As usual, a large number of indents were received after the available supply had been disposed of. There seems to be an exaggerated idea in India as to the resources of the Botanical Section at Pusa both as regards storehouse accommodation and as regards funds. Neither Pusa nor the Bihar indigo estates, which grow wheat for seed, are in a position financially to warehouse large quantities of seed wheat during the monsoon. All wheat, except for seed, has to be distributed at harvest time, a fact which correspondents should carefully bear in mind.

Shipments of Pusa 12 and Pusa 4 to England. In the last annual report, mention was made of a small prelimi-

nary shipment of Pusa 12 to England. This side of the wheat investigations, which is being conducted in co-operation with Mr. B. C. Burt, Deputy Director of Agriculture, Central Circle, United Provinces, has developed rapidly during the past wheat-growing season. The parcel sent to England in 1915 was only 810 maunds, which after several delays, due to congestion at the port of London after the outbreak of the war, eventually reached the mill. It was made into flour by Mr. A. E. Humphries and distributed to the leading millers in England. The reports received were very favourable and larger samples were asked for. This year, over 5,000 maunds of Pusa 12 were collected by Mr. Burt for export which have been shipped to England by Messrs. Ralli Brothers who, as in previous years, are doing everything possible in bringing the new variety to the notice of the trade in Great Britain. As soon as the milling reports are received, a full account of this part of the work will be published.

In addition to Pusa 12, requests were received from the English millers for samples of Pusa 4 large enough for a full milling test. This request was complied with and about 4,000 maunds of this variety have been shipped by Messrs. Ralli Brothers to London, Liverpool and Hull. Three quarters of this parcel was grown in Bihar on the Dholi, Belsund and Hathowrie estates while the remaining 1,000 maunds came from some of Mr. Burt's wheat centres in Bundelkhand.

Other wheat investigations. In addition to the work relating to seed-distribution and to the establishment of new grades of wheat in India, a large amount of time continues to be devoted to the various wheat investigations in progress at Pusa.

Four series of exceedingly promising new crosses are being worked out in detail. In all these an effort is being made to combine rust-resistance, standing-power, grain quality and yield in the same type. It is expected to evolve from these new forms a set of wheats which will replace all those now under cultivation and also make the most of

India's possibilities as a future producer of wheat. Before they can be distributed to advantage, however, much remains to be done in improving wheat-growing including the control of irrigation water and the proper management of alluvial soils. At present, only a few inches of the surface soil of the great plains are being utilized by the wheat crop and the cultivation of deep-rooting, high-yielding kinds is out of the question. When the need for surface drainage is understood and when the importance of soil-aeration is realized, the wheat crop will be able to make use of a much thicker layer of the alluvium than is now possible. The proper use of green-manure will also increase the rapidity of growth. When these improvements have been adopted, the way will be open for the successful introduction of the new wheats now being made at Pusa.

Tobacco.

Evidence of the popularity of Type 28 for cigarettes and its suitability for widely different soils and climates continue to increase. The Bihar ryots who are growing leaf for the various branches of the Indian Leaf Tobacco Development Company, are demanding the seed of this type in larger and larger quantities, the distribution being carried out by the Dalsing Serai Branch. In Burma, Mr. McKerral reports that Type 28 is doing well for cigarette purposes and that a scheme of seed-distribution is under consideration. In the United Provinces, Mr. Burt has obtained good results with this variety and seed distribution in two Districts is contemplated. Some time ago, very good crops were obtained in the Central Provinces by Mr. Clouston. To meet the increasing demand for seed, nearly half an acre was allowed to flower last season and measures were taken to prevent cross-fertilization. If still larger quantities of protected seed are asked for, the expense involved will be considerable and it may be necessary to ask Government to increase the annual grant for this section.

At the present time in Bihar, the chief direction of progress in tobacco growing is the discovery of some means of lowering the cost of production of this crop. The two chief items in this expenditure are, firstly, the labour involved in the management of the monsoon fallow which precedes tobacco and, secondly, the cost of the manure required. Both these matters have received attention in the Botanical Section. The cost of the monsoon fallow has been reduced by the introduction of the five-tine spring-tooth cultivator by which the efficiency of the plough cattle has been increased threefold and by which it has been possible to keep these fallows clean even in wet years. With regard to the cost of manuring, a method has now been discovered by which heavy, well-ripened crops of leaf can be obtained with green-manure alone. The successful use of *sanai* (*Crotalaria juncea*) as a green-manure for tobacco in Bihar has been found to be a matter of soil-aeration. In the decay of the green crop, a vast amount of oxygen is required and a corresponding volume of carbon dioxide is produced in the soil. For this decay to take place with the necessary rapidity under monsoon conditions, it has been found necessary to promote aeration by suitable surface drainage and by the provision of a certain amount of broken tile (*thikra*) in the surface soil. Under such conditions, the tobacco crop does not suffer from want of air during growth and the ripening processes are not delayed as is the case in green-manuring in the ordinary way. Proceeding in this manner, namely, by green-manuring on drained land containing *thikra*, a crop of cured cigarette tobacco weighing 24 maunds to the acre was produced, which was sold to the Indian Leaf Tobacco Development Company at Dalsing Serai for fifteen rupees a maund. The product was cured on the ground in the country fashion, care being taken to use the minimum amount of moisture in the process. The application of this method under estate conditions is naturally a question of the capital involved in the addition of the necessary amount of *thikra* to the soil. An area of land is now under treatment on the Dholi estate and it is

proposed to publish from time to time the value of the annual produce so that this can be compared with the capital involved in the improvement. There is no doubt of the effect of *thikra* in increasing the value of green-manure. The question that remains for decision is whether the improvement will pay under present conditions. It is expected that the Dholi results will answer this question.

Indigo.

In the last annual report, a detailed account was given of the results of our study of the wilt disease of Java indigo and of the importance of soil-aeration in the development of the roots and root-nodules of this crop. The question of the production, on the Bihar estates, of the seed of Java indigo was also dealt with and the conditions necessary for success were outlined. The general experience of the past indigo season supplied an interesting confirmation of the views put forward in the first and second reports on the improvement of indigo. The monsoon of 1915 in North Bihar was heavy and well-distributed and, in addition to the rainfall, there occurred a series of floods which on most estates cut short indigo manufacture and killed out large areas of the crop. The weather during the first half of August—the period when Java indigo has to be sown for seed—was very wet and few breaks occurred. The almost continuous rainfall after the seed crop was sown, coming as a re-inforcement to the heavy falls in July and the floods, so consolidated the soil and interfered with its aeration that on a comparatively few estates only did the seed crop do well. It was only in cases where the surface drainage was good and the natural aeration of the soil was above the average that Java indigo sown for seed was able to grow normally and produce an average outturn. On the heavier soils in the submontane tract and on the lighter lands which had been flooded previous to sowing, the soil-aeration was so interfered with that the seed crop was attacked by *Psylla* and proved a complete failure. On some of the drained plots at Pusa, the seed crop was distinctly

yellow after the late October flood and a good deal of leaf was lost while the sub-soil was drying during November and December. During the cold weather, the aeration improved and the foliage then became normal both as regards colour and extent.

In the case of Java indigo sown for leaf in early October on the higher lands, quite different results were obtained. After sowing time, little or no rain fell till March and so there was nothing to interfere with the natural aeration of the soil. In many cases, this leaf crop gave small crops of excellent seed, a phenomenon which does not often occur in years when the normal amount of cold weather rainfall is received.

This experience agrees in all respects with the results of the various experiments in growing Java indigo for seed at Pusa. Seed formation, other things being equal, is a matter of soil-aeration. If ample air for the roots of Java indigo is provided, a full crop of seed is obtained. Just as surely heavy and long-continued rain after sowing destroys all hope of a normal yield of seed even when the crop recovers slowly during November and December. In all such cases, the season is missed and flowering begins too late after the cold season has set in and the bees have finished their labours.

As seasons like that of 1915 are to be expected every now and then in Bihar, experiments have been started to determine whether it will pay to treat some of the higher lands on the indigo estates with *thikra* so as to increase the aeration in wet years. These are in progress both at Pusa and at Dholi and the results will be published in due course. At the same time, experiments are in progress to see how far suitable methods of cultivation of the young seed crop will remedy the effects of heavy rain after sowing.

Gram.

An account of the preliminary work on gram was published during the year in the *Memoirs of the Department*

of Agriculture in India. A number of types have been isolated which are being tested for yield under various conditions. A few of these have been distributed for preliminary trials outside Pusa.

As pointed out in the last annual report, the yield of gram like that of indigo depends on the aeration of the roots and nodules. If, however, this crop is grown on well ventilated soils which are also rich in combined nitrogen, the yield of seed always falls off although the amount of growth is enormous. When the crop obtains a large amount of nitrate in solution from the soil and also forms nodules, it is overstimulated and readily becomes too rank. The heaviest and best-ripened gram is always grown at Pusa on well-aerated plots which are distinctly poor in available nitrogen. In the past season, the best crop of gram was obtained by late sowing on a *thikra* plot immediately after the removal of a heavy crop of *patwa* (*Hibiscus cannabinus*). Java indigo grown for seed sometimes behaves in a very similar manner and experiments on this point are now in progress.

Oil-seeds.

The work so far done on safflower (*Carthamus tinctorius*, L.) and *rai* (*Brassica juncea*, H. F. and T.) has just been published in the Botanical Memoirs.

The study of Indian linseed has been begun and an attempt is being made to produce a large seeded linseed for the plains. At present, the types grown on the alluvium have very small seed, the large seeded forms being produced on the soils of Central India. These two classes of varieties are otherwise quite different—those from Central India with large seeds having a deep root system to suit the black soils while those of the plains are surface rooted. Crosses are being made between these types with the object of producing for the alluvium new surface-rooted kinds with large bold seeds. In addition to the inheritance of size of seeds, this study ought to provide interesting results on the genetics of root-development.

Soil-aeration.

The preliminary results obtained on the aeration of soils in India were published during 1915 as Bulletin 52 of the Pusa Institute. A considerable amount of interest has been aroused by this publication of which a second edition was called for during the year. This paper was reviewed very favourably in *Nature* of February 24th, 1916, and has been well received in Europe. A paper on soil-aeration was read at the Indian Science Congress at Lucknow in January last when Mr. Hole, the Imperial Forest Botanist, also gave an account of his work on aeration from the point of view of Indian Forestry. Both these papers attracted a good deal of attention and were keenly discussed.

The views put forward on this subject in Bulletin 52 were amplified and developed in a lecture given to the Board of Agriculture at Pusa last February. This lecture has been passed for printing and will shortly appear as Bulletin 61 of the Pusa Institute. In this paper, the connection between soil-aeration and the development of quality has been outlined and considerable space has been devoted to the practical applications of soil-ventilation including the saving of irrigation water and the increase in crop-production in the plains of India.

Surface drainage.

As in the case of soil-aeration, the publication of Pusa Bulletin 53 on soil-erosion and surface drainage has led to such a large demand for copies that a second edition of this paper had to be arranged within a year of the appearance of the first. This bulletin was written largely as an introduction to the discussion on these subjects which took place at the last meeting of the Board of Agriculture. The views put forward in this paper were accepted by the Board and three resolutions, largely based thereon, were recommended to the consideration of the Government of India.

Interest continues to be taken in the Pusa system of surface drainage which is to be seen at Dholi on an estate

scale. A large number of visitors saw this estate during the year and this method of drainage is now being taken up in Bihar. His Highness the Maharajah of Darbhanga is showing a personal interest in this matter and a beginning has been made on several of his estates. In this work Mr. R. S. King, Sub-Manager of the Jhanjharpur Circle of the Raj, is taking the keenest interest both in local drainage schemes on the Darbhanga properties and also in the scheme for the preparation of a contour survey of North Bihar. In the United Provinces, the Pusa method of drainage has been adopted at two centres and results similar to those in Bihar have been obtained.

Perhaps the most notable advance in drainage in Bihar during the year is the fact that the Commissioner and the District Embankment Committees of the Tirhoot Division are taking up the question of the general drainage of Bihar on the basis of a drainage map, constructed on the lines of the system introduced by the late Sir Edward Buck. A joint meeting of the District Embankment Committees of the Division was held at Muzaffarpur in December 1915 when the general lines of future work on this subject were discussed.

III. The Development of the Agriculture of Baluchistan.

Although started for local objects, the foundation of the Fruit Experiment Station at Quetta has led to the discovery of results of considerable importance to Indian Agriculture. These apply particularly to the irrigated tracts of India and are concerned with the saving of water in wheat-growing and with improved methods of growing fodder crops.

Water-saving.

The earlier results on water-saving in wheat-growing were published during the year in Bulletin No. 4 of the Quetta series. In this paper, the opportunity was taken of stating very briefly the main principles on which the right use of irrigation water depends. A careful com-

parison of these principles with the practices in vogue in the irrigated areas of Baluchistan cannot fail to show that an enormous quantity of valuable water is now being wasted. As the principles underlying water-saving are not understood and little has been done in utilizing the present supplies to the best advantage, it will not be out of place briefly to refer to them here. Both experience and experiment prove that if the maximum duty of irrigation water in wheat-growing is to be obtained, special attention must be paid to the following five principles :—

1. The irrigation water available must be spread over the largest possible area.

2. Heavy waterings reduce the proportion of grain to total crop.

3. The growth period of wheat is increased by heavy waterings.

4. When the water supply is limited, the root development of the wheat crop must be deep.

5. The soil moisture must be preserved, as far as possible, by a surface mulch of dry soil.

Applying these principles to the conditions of the Quetta valley, it was found that the highest duty of water could be obtained by irrigating the land once a few days before sowing and by breaking up, by means of the lever harrow, the rain crusts formed during winter and spring. The average yield on large scale trials on unmanured land at the Experiment Station worked out at $17\frac{3}{4}$ maunds of grain per acre. The zamindars, on the other hand, often water their wheat six times after sowing and obtain an average of $13\frac{1}{2}$ maunds of grain. The same amount of water spread over seven acres, if used according to the method employed at the Experiment Station, would give 7 times $17\frac{3}{4}$ or $124\frac{1}{4}$ maunds of wheat. The difference in favour of the experiments is therefore $110\frac{3}{4}$ maunds of wheat. If the average irrigated acreage of wheat in the Quetta valley is multiplied by 100, the result would indicate, in maunds of wheat per annum, the present annual waste of water on this crop alone. On every 200 acres of

irrigated wheat, the water now lost would produce 20,000 maunds of grain and a large amount of straw of a total value not far short of a lakh of rupees.

During the past wheat season, the new methods have been tried on zamindars' land near Quetta. One watering was given at the end of September before sowing and in spite of the fact that the winter rains did not set in till late in January, two months later than usual, a very good crop resulted, the grain of which was well above the average in quality. The yield of grain was 22 maunds 32 seers per acre, while the *bhusa* amounted to 43 maunds 20 seers. This result, in spite of the lateness of the winter rains, is five maunds higher than the average obtained at the Experiment Station. This is due to the fact that the wheat land at the Experiment Station is high-lying, exposed to the sun and wind and its water-holding capacity is less than that of the typical wheat lands of the valley. The Experiment Station yields have therefore been exceeded by the zamindars in a season of badly distributed rainfall when the local dry-crop wheat was a failure.

These results have naturally attracted a considerable amount of attention. On May 29th, a meeting of the *maliks* of the valley was arranged at the demonstration area when the Agent to the Governor-General and the chief officials of the Baluchistan Administration were present. On June 5th, the Political Agent brought the *maliks* of the Pishin valley to see the results. These visits were entirely successful, a keen interest was shown by those present and large areas of land were at once offered for demonstration work for the next season's wheat crop. Sir John Ramsay has ordered 25 pairs of lever harrows, some of which will be given as *khillats* at the September *Darbar*. The irrigation policy of the Administration has recently been revised, partly as a result of these experiments and particular attention will, in future, be paid to water-saving and to the increase in the duty of the present supplies.

The investigations on water-saving are being continued and during the year further results were obtained, an

account of which is now being prepared for publication. These refer to the improvement of water channels, to the most suitable form of *kiari*, to the proper slope for flood irrigation and to the control of the water while being applied to the land.

The improvement of fodder production.

In addition to the saving of irrigation water, there is another direction in which the productive power of the land in Baluchistan can be increased. This is in the provision of a fresh source of organic matter for supplementing the present supplies of farm-yard manure. The addition of organic matter to the soils of the Quetta valley does much to increase their porosity and water-holding capacity and also to mitigate the evil effects of surface-flooding. The growth of Persian clover (*Trifolium resupinatum*), locally known as *shaftal*, has been found to improve the cropping power of the land very considerably and to be a valuable source of organic matter, particularly if the last crop is ploughed in as a green-manure. It also supplies a large quantity of valuable fodder and is a simple means of utilizing the winter rains.

Some attention has been paid to increasing the yield of *shaftal* and other crops at Quetta, and to the best means of improving the duty of water in fodder growing. Such crops grow faster and need less water, if the land is manured in the first instance with farm-yard manure at the rate of 15 to 20 tons per acre. The proper grading of the surface and the use of long *kiaris* (about $300' \times 25'$) watered from one end of the field leads to an even flow of the irrigation water over the land and to uniform percolation. In this way, a great saving of water takes place. The expense and trouble of the preliminary grading and levelling and of the adoption of the most suitable form of *kiari* are well repaid by the amount of water saved, by the ease with which irrigation can be carried out and by the evenness of the resulting crop.

During the past season, one of the plots at Quetta, which was not in very good condition, was put down in

shaftal in August 1915. The land was manured with farm-yard manure at the rate of about 20 tons per acre and sown with *shaftal* under a thin cover-crop of maize. Six cuts of clover were obtained by the middle of June 1916, the total weight of which was over 33 tons per acre. At eight annas per 100 lb., the year's produce is worth Rs. 371 per acre—an income obtained with the minimum expenditure of water and resulting in an increased fertility of the land. This result, which has been confirmed many times at Quetta, indicates the methods which should be adopted in fodder growing in India—intensive cultivation with the minimum expenditure of irrigation water.

While *shaftal* has proved a useful green fodder, particularly for dairy cows and buffaloes, its best use to Baluchistan is in the form of clover hay, put up in bales suitable for storage and for easy transport on mules or camels. Real hay is unknown in India, its place being taken by in-nutritious substances like dried grass and *bhusa*. A considerable amount of attention has therefore been paid to the drying and baling of *shaftal* and to the preparation of real hay. In European countries, the difficulties in hay-making are concerned largely with the slow rate of drying and with the interference caused by frequent showers. At Quetta, the problem is reversed. The air is so dry and the sun is so strong that the hay easily becomes overdried and so brittle that it is broken to powder when handled. Baling such a product is out of the question and even if it could be stacked, no mild after-fermentation could take place. These difficulties are overcome by drying in stages in heaps on the field and by preserving sufficient natural moisture for a slight fermentation to take place in the stack before baling. Early last year, trials of the new baled fodder were carried out with the horses of the 72nd Heavy Battery at Quetta under the Commandant, Colonel H. M. Courtenay, R.A., who reported very favourably on the results. The transfer of this unit and the death of the Commandant on active service put an end to the trials. They have, however, been continued by Brigadier-General

Cook, R.G.A., with one of the mule teams of the 4th Mountain Battery. The trial has been a great success and the mules did better on *shaftal* hay than on their ordinary ration of *bhusa* and grain. The saving in weight was about 30 per cent. and the cost was also substantially reduced. There is now little doubt that the use of baled *shaftal* as fodder for Army purposes would mean a reduction in the weight of forage of some 30 per cent., a point of considerable importance on the Frontier where the difficulties of transport are so great.

Shaftal and lucerne are by no means the only leguminous plants in North-West India, that could be made into hay and pressed into bales. There should be no difficulty in drying and pressing crops like *berseem* and *senji* which are already cultivated in Sind and the Punjab respectively. The albuminoid ratio of such fodders is much above that of *bhusa* and there is a great opening for such produce both in the Army and also in the cities and on the main roads of North-Western India. Later it might spread to the cultivators and for the building up of fodder reserves for use in time of famine. Once such fodders as *shaftal* hay find their way into Indian agriculture, the efficiency of the ox, on which the system rests, will increase and at the same time the producing power of the land will improve.

Besides their local significance, these results on water-saving and fodder-growing have a distinct bearing on the development of Indian Agriculture. To anyone who can read his practice in the plant, there can be no doubt that in the irrigated tracts of the country, a great waste of valuable irrigation water is going on which is not only lost but also damages the standing crops and tends to lower the general fertility of the country. There are many tracts in India where a perennial system of irrigation is scarcely suitable and where the duty of water might be increased by working on older lines and by substituting in its place a modified form of inundation. The problem of using the present supplies of water in India in wheat-growing is largely physiological and depends for its solution on a knowledge

of the functions of the plant. Crops like wheat require a well aerated soil as well as a sufficient supply of moisture. The continual surface flooding which takes place in a perennial system of irrigation destroys the natural texture of the soil and interferes with its aeration. The addition of more water to a crop in which the yield is already limited by want of air cannot possibly produce any useful result. Particularly is this the case on the fine alluvial soils of the plains and on the black soils of the Peninsula. The problem of obtaining the maximum duty of water is to supply moisture without depriving the soil of air. In many cases, this can be accomplished by a single irrigation before sowing followed by moisture conservation methods like those adopted at Quetta. In other cases, the amount of water can be reduced by increasing the water-holding capacity of the soil by green-manure and by other methods now being worked out. Any saving of irrigation water in India is an advantage both to the people and to Government. The less water used the less is the damage done to the country and the larger is the area irrigated. Government benefits by a growing revenue and by increased opportunities for the settlement of discharged sepoys and of the surplus population of congested districts. Under the present system of perennial irrigation, India is rapidly reaching the limit of profitable expansion with the water now available. Any great extension must be achieved by increasing the duty of water, a problem full of possibilities for the country but one on which hardly any attention has yet been bestowed.

Fruit investigations.

It is proposed to defer till the next annual report any detailed account of the results which are now rapidly accumulating with regard to the cultivation and propagation of fruit trees and to the transport of the fruit itself. Many of the problems relating to these matters are on the point of solution and in another year the subject can, in all probability, be dealt with much more definitely and satisfactorily than at this moment.

Improved fruit boxes. As far as the design of suitable fruit boxes for the Quetta trade is concerned, this portion of the work may be said to be completed. The only thing that remains is the discovery of the cheapest and most satisfactory source of the box boards and cardboard. A large amount of time has been spent in trying to discover whether the box boards could not be obtained in India itself. After numerous enquiries, an Indian firm was discovered whose tenders were satisfactory. The execution of the orders, however, left much to be desired and when enquiries were made as to future supplies of a more satisfactory character an attempt was made to increase the price far beyond the value of the material. For the present, it has been found more satisfactory to import the boards from Great Britain in spite of the increase in cost due to the war and to the rise in freights.

The demand for the improved boxes showed a most satisfactory increase during the summer of 1915, and about 3,176 boxes and 2,200 two pound punnets were sold. For many of these packages the demand was greater than the supply and the entire stock was sold long before the end of the season. For 1916, a much larger supply has been procured, more than sufficient for any possible demand that is likely to arise.

The new cardboard boxes have proved a great success and are in active demand. These can be used as returnables and last for three or four journeys to and from Quetta. In this way, the expense is reduced and the cost of the package each journey for five seers of choice peaches comes to less than four annas. Another advantage of these cardboard boxes is that they are thief-proof and cannot be tampered with in transit without immediate detection.

One indirect result of the new boxes should be mentioned, namely, the stimulus they have given to new planting. A great demand for nursery stock has arisen and many large fruit gardens are being put down. To meet this, the number of trees issued by the Fruit Experiment

Station is being rapidly increased and by the end of 1917, it is expected that all possible requirements can be met.

IV. Programme and publications.

Programme of work for 1916-17.

Work will be continued on the following crops on the lines indicated in the annual reports and in the publications of the section—wheat, tobacco, gram, fibre plants, indigo, oil-seeds, fodder crops and fruit.

Publications.

The following papers were published during the year. In order to bring the list up to date and to make it correspond with this report, all papers in the press which are due to appear before the end of July 1916, have been included. The Urdu editions of three of the Quetta Bulletins were prepared by members of the staff of this section :—

1. Soil aeration in Agriculture. *Bulletin 61, Agricultural Research Institute, Pusa,* 1916.
2. Soil ventilation. *Bulletin 52, Agricultural Research Institute, Pusa,* Second Edition, 1916.
3. Soil Erosion and Surface drainage. *Bulletin 53, Agricultural Research Institute, Pusa,* Second Edition, 1916.
4. Report on Agricultural Botany for 1914-15, for the Board of Scientific Advice.
5. The importance of soil ventilation on the alluvium. A paper read at the Indian Science Congress, Lucknow, 1916, and published in the special Congress number of the *Agricultural Journal of India,* 1916.
6. The Application of Botanical Science to Agriculture. A paper read at the Indian Science Congress, Lucknow, 1916, and published in the special Congress number of the *Agricultural Journal of India,* 1916.
7. The manurial value of potsherds. *Agricultural Journal of India,* Vol. XI, Part 3, 1916.
8. Some improvements in the packing and transport of fruit in India. *Bulletin 2, Fruit Experiment Station, Quetta,* Second Edition, revised, 1915.

9. Soil ventilation. *Bulletin 3, Fruit Experiment Station, Quetta*, 1915.
10. The saving of irrigation water in wheat-growing. *Bulletin 4, Fruit Experiment Station, Quetta*, 1915. Reprinted in the *Agricultural Journal of India*, Vol. XI, Part 1, 1916.
11. Clover and Clover Hay. *Bulletin 5, Fruit Experiment Station, Quetta*, 1915. Reprinted in the *Agricultural Journal of India*, Vol. XI, Part 1, 1916.
12. An improved fibre plant. *Agricultural Journal of India*, Vol. X, Part 3, 1915.
13. Some varieties of Indian gram, *Cicer arietinum*, L. (with Abdur Rahman Khan). *Memoirs of the Department of Agriculture in India (Botanical Series)*, Vol. VII, No. 6, 1915.
14. Studies in Indian oil seeds. No. 1. Safflower and Mustard (with Abdur Rahman Khan). *Memoirs of the Department of Agriculture in India (Botanical Series)*, Vol. VII, No. 7, 1915.
15. On the inheritance of some characters in wheat—II. *Memoirs of the Department of Agriculture in India (Botanical Series)*, Vol. VII, No. 8, 1915.
16. The wheats of Baluchistan, Khorasan and the Kurrum Valley. *Memoirs of the Department of Agriculture in India (Botanical Series)*, Vol. VIII, No. 1, 1916.
17. The storage of seed. *Agricultural Journal of India*, Vol. X, Part 3, 1915.
18. A new seed-drill. *Agricultural Journal of India*, Vol. X, Part 3, 1915.
19. Mixed crops. *Agricultural Journal of India*, Vol. XI, Part 3, 1916.
20. Zamin men hawa ki ámad va raft. *Risála 3, Quetta*, 1916.
21. Gehun ki ábpáshi men kifait shuari. *Risála 4, Quetta*, 1916.
22. Shaftal aur uska khamir shuda khushk chárá. *Risála 5, Quetta*, 1916.

REPORT OF THE IMPERIAL MYCOLOGIST.

(E. J. Butler, M.B., F.L.S.)

I. Charge and Establishment.

Mr. F. J. F. Shaw, B.Sc., A.R.C.S., officiated as Imperial Mycologist until November 16th, 1915, when I resumed charge of the section on return from combined leave. The post of Second Imperial Mycologist was created during the year and filled by Mr. Shaw, Supernumerary Mycologist, on October 19th, 1915. Muhammad A. Hafiz Khan, 3rd Assistant, was transferred on deputation to the Forest Research Institute, Dehra Dun, with effect from September 22nd, 1915. The vacancy thus created was filled by promotion from the staff, Babu N. C. Sen coming in as second clerk. Five of the staff volunteered for service in Mesopotamia in connection with the campaign against flies, just before the close of the year, and two of these have since been accepted. All have worked well.

II. Training and Visitors.

Babu J. B. Sinha, Fieldman in Mycology, Sabour, completed his course of training at Pusa on September 29th, 1915. Babu K. P. Roy, a scholar from the Bengal Department of Agriculture, joined on August 10th, 1915, and finished his course on May 31st, 1916. Mr. Deoki Nandan, B.A., M.R.A.C. and Mr. B. N. Vakil took special courses as private students from May 23rd and between March 15th and April 25th, respectively. Prof. K. C. Mehta, M.Sc., Professor of Botany, Agra College, worked in the section from March 3rd to 26th and Mr. G. S. Kulkarni, Mycological Assistant, Bombay, Department of Agriculture, from March 23rd to May 24th. Mr. A. C. Tunstall, Mycologist to the Indian Tea Association, visited the section from January 15th to 25th, 1916.

III. Diseases of Plants.

The investigation of the diseases of plants, the collection and identification of Indian parasitic fungi, and advice and assistance to officers of the Department and the general public, formed as usual the chief work of the section.

(1) Paddy diseases. The most important disease at present under investigation in the section is that known as "ufra" of rice, which continues to extend and attract increasing notice in Eastern Bengal. It is now throughout most of the districts of Noakhali, Tippera and Dacca and is extending into Mymensingh and probably Sylhet. With a view to testing measures for checking its ravages by experiments within the affected area, I selected a site near Comilla in 1912, and arranged for its acquisition as a temporary measure and also for complete control of its water supply by bunding, to prevent risk of infection from neighbouring fields. Subsequently it was decided by the local Department not to acquire the land, arrangements being made with the cultivators in the selected area to carry out our instructions. This did not prove satisfactory; the instructions were not followed, the bunds were defective and were cut through when water became scanty and the crop was harvested before it could be inspected. Owing to the evident difficulty of securing effective control of the selected site, it was abandoned last year and arrangements have been made to carry on the work in the neighbourhood of Dacca. Meanwhile small plots were instituted at Pusa in 1912, in order to duplicate the work under more rigorous control. It has been necessary to confine the Pusa work within narrow limits to avoid risk of the disease escaping from the plots to the surrounding cultivation; and only one or two experiments have been possible each season, outside those which could be carried on in the laboratory. The information obtained has, however, been considerable. It has been proved that a diseased plot will inevitably give a diseased crop the following year, if the stubble is allowed to rot on the ground as is the usual practice in the infected

area, but that if all the stubble is removed, a healthy crop can be grown. Furthermore it has been shown that the parasite can extend along the water courses, both with and against the stream, and infect neighbouring plots, but the distance travelled has hitherto been small. When atmospheric humidity within the crop is low, extension is hindered, but provided the humidity conditions are right, new cases of disease may become evident even on large plants within a month and many plants may be destroyed within two months of liberating the parasite in the water supply. Though under normal conditions the parasite passes into a dormant condition in the rotting stubble in the interval between successive crops (say from December to April), it can be kept in an actively parasitic state through this period by supplying it with constantly renewed young growing paddy for food, and this fact may increase our difficulties in dealing with it where the crop known as *boro* paddy is grown, fortunately a relatively small area. On present information it seems probable that the *boro* crop harbours the parasite, but that the low atmospheric humidity during the winter and spring months, when this crop is growing, checks extension and perhaps also interferes with the multiplication of the parasite. It is this same factor that doubtless explains the relatively little damage caused to the early (*aus*) crop and to the main crop in its early stages; experiments at Pusa have shown that so long as the above-ground parts of the plant are maintained dry, it is difficult to get successful infections, even though the roots and base of the plant are in mud and water, whereas during the monsoon or when inoculated plants are covered by bell jars, infection readily occurs. When insufficiently provided with moisture the parasite tends to pass into a dormant condition and ceases feeding.

Laboratory work was directed to attempts to establish conclusively that the cause of the disease is *Tylenchus angustus*, the eelworm described in Bulletin No. 34 of 1913. Attempts to obtain it in pure culture failed but conclusive proof was ultimately got by a series of experiments which

established that minute portions of infected plants were only infectious when they contained on them individuals of this species. During these experiments it was found that definite symptoms may be induced in healthy seedlings within a week when a moderate number of worms is used for inoculation. A minute strip of plant carrying, say, 20 worms can be relied on to produce the disease in covered seedlings, while a similar strip from the same plant and part but without worms, is harmless. About a hundred successful inoculations have now been carried out under conditions which leave no room for doubt that the actual parasite is this worm—perhaps the first case in which an ectoparasitic eelworm has been found causing serious injury to plants. Other points determined are that the worm is not strictly aquatic, as it perishes in some weeks if wholly immersed in water. Kept dry it lives longer, as it has the faculty of coiling itself up into a twisted mass, which resists moderate desiccation for at least some months. It appears to be unable to grow much or moult unless supplied with its usual living food and hitherto has not been found to grow or feed on anything else than living paddy plants. On paddy it is limited to parts where the outer walls of the epidermal cells are unthickened, and in young plants penetrates the bud to reach the young leaves near the growing point as soon as possible. This position is reached not by burrowing through the tissues but entirely by passing between the folds of the bud. Several experiments were carried out to test the ability of the worm to remain alive in soil, and the results indicate that it cannot survive during the interval between successive crops in this manner.

All the work hitherto carried out confirms the conclusion previously arrived at that the parasite is normally perpetuated by means of the stubble, which it is the practice in the infected area to leave on the fields after harvest. The problem of dealing with the disease therefore resolves itself into ascertaining the best way of removing or destroying this stubble. This can be done thoroughly by

raking it into heaps and burning it. It can perhaps be equally effectively carried out by early ploughing so as to bury the debris of the previous crop. Both these methods, however, are likely to interfere, if carried out on a large scale, with the local fodder supply and it seems necessary to ascertain whether diseased straw can safely be fed to cattle. There will be no need to defer active operations while such relatively minor points are being investigated, and it is hoped that the destruction of the stubble will be attempted on a large scale in the near future.

(2) " Tokra " of tobacco and mustard. The work of past two seasons has established that the parasitic species of *Orobanche* in Bihar are *O. indica* Ham. and *O. cernua* Loeffl. The species *O. cernua* is the common parasite of solanaceous crops in Bihar but does not appear to attack *Cruciferæ* save in very exceptional circumstances. In a crop of mustard, grown in a field known to be badly infected with both species of Orobanche, only four cases of *O. cernua* were found among many thousands of *O. indica.* The parasitism of *O. cernua* therefore is more restricted than is that of *O. indica* which, while being a serious parasite of *Cruciferæ*, does occur to a not inconsiderable extent on *Solanaceæ.* The life histories of the two species seem to be identical, the " tokras " appearing a few weeks after the host crop is well established and rising to flower and fruit along with it. Both species rely on the production of countless millions of minute seeds for their dissemination and perennation. These seeds are present all over the cultivated lands of Bihar, their number and minute size being extremely favourable to their dispersal in the strong winds of February and March when the fruits of *Orobanche* are ripe.

Experiments were carried out during the year with a view to discovering whether the addition of quantities of sodium nitrate to crops of mustard and tobacco had any influence on the number of " tokras " which occurred in the crops. Plots of equal size were selected in land which was known to be infected with both species of *Orobanche* and

the numbers of " tokras " occurring in plots to which sodium nitrate had been added were compared with the numbers of " tokras " in plots which had not received any nitrate. A difficulty which renders the results of the first season's work on these lines somewhat inconclusive is that the number of " tokras " appearing in a plot will depend, apart from any influence of artificial manures, on the amount of " tokra " seed which the plot contained. This factor appeared in many cases to mask any effect which might have been due to the addition of sodium nitrate. The work will be continued for another year in order to eliminate this source of error but the results obtained to date do not lend any support to the view that sodium nitrate will be found a specific remedy for " tokras."

(3) Black thread of rubber. Work on the " black thread " disease of Hevea in Burma was continued. A popular account was published as a bulletin of the Burma Department of Agriculture and a more technical memoir is in the press. The disease first breaks out soon after the rains begin and completely disappears after the close of the monsoon. It is not fatal to the tree but does much damage by attacking the tapped area of the bark. Infected areas do not yield latex and severely diseased trees have to be excluded from the tapping round. In 1914 the loss of rubber on one estate was 2—3,000 lb. and in 1915, 8—9,000 lb., there being 12,000 trees affected in 1914 and 42,000 in 1915, out of 77,000 in tapping. The cut surface of the tapped bark becomes marked by vertical cracks, from which latex occasionally exudes; sometimes a thick cushion of coagulated latex forms below the renewing bark, causing the latter to bulge out and ultimately fall off so as to leave an open wound. The renewal of the bark is irregular, masses of callus appear on the cut surface and further tapping is hindered.

The cause of this damage is a species of *Phytophthora*, differing from the well-known canker fungus, *Phytophthora Faberi*, to which it had been attributed in the Dutch Indies. It seems to occur in Ceylon also but has been there

supposed to result from climatic conditions. In South India the same fungus is believed to be responsible for considerable damage and it is at present under study by the Madras Department.

The fungus is found both in the diseased bark and also on the fruits. It has been grown in pure culture and an extensive series of inoculations carried out both on rubber and on numerous other plants known to be attacked by species of *Phytophthora*. On rubber it is a wound parasite, being unable to infect the undamaged bark; through wounds it infects readily and produces the characteristic symptoms of the disease. Of the other plants tried, the ordinary hosts of *Phytophthora infestans*, *Ph. parasitica* and *Ph. Colocasiæ*, the three species most commonly found in Northern India, are immune, as also is cacao, one of the chief hosts of *Ph. Faberi*, and many other plants known to be liable to *Phytophthora* attack. Only on seedlings of the garden plants, *Gilia* and *Salpiglossus*, were successful infections secured.

The disease is favoured by excessive humidity and shade and is, therefore, worst in thickly planted rubber estates. The free admission of sunlight and air checks its progress, and good results may be obtained from judicious pruning and thinning. The chief source of infection seems to be the fruits, and as these have practically no value, and develop in the rains a copious growth of the parasite, from which spores are shed on the bark, it is recommended that all fruits be carefully picked and destroyed before the monsoon breaks, in infected plantations.

In continuation of the studies on allied species of this genus which have been carried on at Pusa in recent years, an account of a form of *Phytophthora parasitica* found on *Vinca rosea* has been recently submitted for publication. Germination of the durable type of spore (the oospore) has been obtained and was found to correspond in essentials with that described for *Ph. erythroseptica* in Ireland.

(4) Opium poppy blight. The investigation of this disease has led to the conclusion that while *Peronospora*

arborescens is a normal parasite present in almost every poppy field and probably, like most of its tribe, only epidemic under favourable climatic conditions for its spread, *Rhizoctonia* develops chiefly in fields in which the drainage is defective. The Economic Botanist, United Provinces, has discovered certain varieties which appear to be almost immune to *Peronospora* and in the growth of these and improved cultivation and drainage lies the best hope of preventing loss of the crop.

(5) *Rhizoctonia* on jute and sugarcane. Samples of jute seed from Dacca were found to contain the sclerotia of *Rhizoctonia Solani* Kühn adhering to the seed. The parasitism of this fungus upon jute has been the subject of a previous publication but up to the present *R. Solani* has been a source of damage in the region of the " collar " and has not been known to infect seed. It is not clear how this comes about and the matter will receive further investigation.

Specimens of sugarcane received from the Central Provinces were found to be infected with a sclerotial fungus. The fungus was obtained in pure culture and strongly resembled *Rhizoctonia destruens* Tass.; moreover inoculations upon *Delphinium* (the original host of *R. destruens*) and upon betle vine were successful. Further infections upon sugarcane resulted in the death of the outer leaves and of the young shoots at the base of the plant; the infections are still progressing at the moment of writing. In the field the fungus causes a bright red spot on the leaf sheath and this is the first noticeable result in artificial infections. In badly diseased specimens the leaf bases are dark red and have a fibrous appearance as if the parenchyma had been rotted away leaving the vascular bundles. On stripping the leaf bases the stem has a pale pink colour under the epidermis and in section the interior shows a generally diffused salmon pink colour partly obscured by a thick white felt of hyphæ. The mycelium shows a tendency to form strands of hyphæ in a manner suggestive of *R. destruens*. Further research is in progress.

(6) Anthracnose of peppers. The disease of betle pepper referred to in previous reports as being probably due to an anthracnose fungus, has proved more difficult to elucidate than was anticipated. All attempts to produce it artificially by inoculating with cultures of the suspected fungi have failed. In the absence of definite knowledge of the cause no useful recommendations for treatment can be offered.

The chilli anthracnose (due to *Colletotrichum nigrum*) is a serious disease of this crop in several parts of India. It was prevalent in Bihar last year and some spraying experiments were tried. Later on it appeared that a more hopeful line of treatment lay in the use of disease-free seed and investigations are in progress to test this method. It has been found that, as in the allied bean anthracnose, the parasite penetrates the pod and reaches the seed. If such seed be sown the following season a certain number germinate and give seedlings on which the fungus may be found. Such seedlings must serve as a source of infection to their neighbours and it seems probable that this is one of the main ways by which the disease is perpetuated. If seed only from healthy pods be used this source of infection can be eliminated, and further experiments are in progress to test the effect of this on the subsequent crop.

(7) Plantain diseases. An account of a plantain disease prevalent at Pusa was published early in the year. It is a wilt, caused by a species of *Fusarium* allied to, but distinct from, that which causes the dreaded Panama disease of the New World. The parasite was grown in pure culture and successful inoculations with it secured. In mild attacks the growth of the plant is not checked but in more severe cases the rot reaches the stem and may kill the whole crown. Much loss is also caused when the stalk of the fruit bunch becomes attacked as this may lead to total destruction of the bunch. No method of treatment has been found.

A second plantain disease, familiar in India, is the fruit rot caused by *Gloeosporium musarum*. Attempts to

check this by spraying have been in progress for a considerable time. It has been found that early spraying with Burgundy mixture, beginning in June and repeated every fortnight until the fruit is nearly ripe, when ammoniacal copper carbonate should be used, is successful in preserving the fruit from the disease. An account of the method has been published.

(8) Sal tree disease. The disease of sál trees, mentioned for the first time in the last annual report of the section, has appeared again this year in the forest of Buxa Duars and is also reported in the Gorakhpur division. The symptoms of the disease and the fungus which occurs on diseased trees are exactly the same as in the previous description. Specimens of the fungus sent to Kew have been identified as *Polyporus Shoreæ* Wakefield—a species new to science—and the description published in the Kew Bulletin. The fungus is said to be readily distinguished from other species by the hard but brittle texture of the pileus, especially of the pores, when dry and the wrinkled deeply cracked dark crust. In living specimens the soft swollen whitish margin of the pileus is a distinctive feature. The basidia are normal and each bears fine hyaline spores from $2{\cdot}5$—$3{\cdot}5\mu$ in diameter.

In culture the fungus grows well on a variety of media. On glucose agar the mycelium is largely submerged and produces a dense brown pigment; the hyphæ very often segment into spores. On sterile corn meal the fungus nearly always produces structures which suggest fructifications; so far however they have not produced any basidia or spores. The excretion of a yellowish liquid is a feature common to these structures in culture and to the pileus in the field.

Inoculations were carried out in the jungle at Rajahbhatkhawa in September of last year but defects in the method of this preliminary experiment, combined with the lateness of the season at the time of making the infection, proved unfavourable, and no conclusive results have so far been obtained. The inoculations were repeated this June,

with modifications suggested by the previous experiment, and a further series of infections is about to be carried out at Dehra Dun in co-operation with the Forest Botanist; it is hoped that these will yield decisive results.

(9) **Other diseases of interest.** The "black-dot" disease of potatoes caused by *Vermicularia varians*, was reported from Ranchi during the year. It was previously known only in France, Australia and South Africa. The extent of the injury it can cause is not yet determined. Peach leaf curl was found in the same locality and is reported to be very prevalent around Peshawar. It is hoped to arrange for trials in its treatment during the coming year. A disease of shaftal (*Trifolium repens*), caused by *Polythrincium Trifolii* (new to India) was found near Peshawar. Diseases of barley were much in evidence in the Pusa crop last season, the chief parasites recorded being *Puccinia simplex* and *Ustilago nuda* (not previously seen in India), *Puccinia glumarum*, *Ustilago Hordei* and *Helminthosporium gramineum*. A case of serious injury to a mango orchard at Malda from the fumes of a brick-kiln was examined. It differed from previous cases of the kind in the injury being chiefly to the fruit, not the branches. It is evident that the mango is peculiarly susceptible to such fumes. The study of the smuts of jowar, which are amongst the most destructive diseases in India, has been taken up by Mr. Kulkarni, Mycological Assistant to the Bombay Department of Agriculture, who completed his investigation at Pusa. No less than four distinct species attack this crop but the two more usual forms can readily be prevented by seed treatment. It is hoped to secure the universal adoption of this treatment ultimately, with a saving to the cultivators of several crores of rupees annually.

IV. Miscellaneous.

During my absence on leave the manuscript of a book on fungi as a cause of plant disease in India was almost completed. It has since been finished and revised and the

preparation of illustrations is now in hand. While engaged at Kew on this work an opportunity was taken of checking the nomenclature and determining the identity of many of the fungi that are responsible for crop diseases in India, by comparison with type material from the Herbarium of the Royal Botanic Gardens. I have to acknowledge the generous facilities given me by the Authorities at Kew and invaluable assistance from the Herbarium staff, especially Miss Wakefield and Messrs. Massee and Cotton.

As a result of the International Phytopathological Conference held at Rome early in 1914, the possibilities of legislation for the control of the spread of plant diseases have been recently much discussed. With the permission of the Secretary of State, I prepared a note for the Royal Horticultural Society on the dissemination of parasitic fungi as a basis for international legislation. This has since been written up with special reference to Indian problems and submitted for publication as a memoir of the Agricultural Department. At the Rome Conference a draft International Convention was signed by the delegates of some 30 States, and India will probably have to decide whether to adhere to this Convention or not, in the near future. Much consideration has been given to this question during the past year so that we may be in a position to advise when called on to do so.

V. Systematic Work.

The fifth part of "Fungi Indiæ Orientalis," based on material sent to Germany before the war, was published during the year. It includes a first instalment of determinations of the Pusa Herbarium collections of *Deuteromycetes*, comprising the *Sphaerioideæ* (173 species), *Nectrioideæ* (7 species), *Excipulaceæ* (4 species), *Leptostromataceæ* (3 species) and *Melanconiaceæ* (8 species). Seven new genera and 97 new species are described, the large proportion (nearly 50 per cent.) of new forms being due, no doubt, to the relatively little attention previously devoted to this group in the East. Many of them are crop parasites but

they are not, on the whole, responsible for as much damage as the mildews, rusts and smuts. The number of mounted sheets added to the herbarium during the year was 258.

VI. Programme of work for 1916-17.

(1) *Research work.* New fungus diseases of crops will be investigated as occasion arises but the following diseases will receive special attention and will constitute main lines of investigation.

(1) Ufra of paddy
(2) "Tokra" of tobacco and mustard
(3) Sclerotial disease and smut of sugarcane
(4) Wilt diseases of cotton, sesamum, gram and chilli
(5) Root rot of sál tree.

As minor investigations it is hoped to continue work on the anthracnoses of some field crops (especially chilli) and fruits.

(2) *Systematic work.* This will probably be in abeyance for the present, owing to difficulties in obtaining assistance from abroad on account of the war.

(3) *Training.* This will be continued on the same lines as in previous years.

(4) *Routine work.* Advice and assistance will be given as usual to Provincial Departments of Agriculture, the Forest Department, Planters' Associations and the general public.

VII. Publications.

(1) Shaw, F. J. F. & S. L. Ajrekar. The genus Rhizoctonia in India. *Mem. Dept. of Agri., India, Bot. Ser.* VII, No. 4, August, 1915.

(2) Shaw, F. J. F. . Report on Mycology, 1914-15, for the Board of Scientific Advice.

(3) Dastur, J. F. . A Rot of Bananas. *Agr. Jour. of India,* Vol. X, Part 3, July, 1915.

(4) Dastur, J. F. . Spraying for Ripe-rot of the Plantain Fruit. *Agr. Jour. of India,* Vol. XI, Part 2, April, 1916.

(5) Dastur, J. F. . Black Thread disease of Hevea in Burma. *Bull. 14, Department of Agriculture, Burma*, 1916.

(6) Sydow, H. & P. & E. J. Butler. Fungi Indiæ Orientalis. *Annales Mycologici*, XIV, Nos. 3 and 4, 1916.

REPORT OF THE IMPERIAL ENTOMOLOGIST.

(T. Bainbrigge Fletcher, F.L.S., F.E.S., F.Z.S.)

I. Charge and Establishment.

The Imperial Entomologist held charge of the Section throughout the year ended 30th June 1916. The post of Supernumerary Entomologist remained vacant throughout the year owing to the impossibility of obtaining any suitable candidate during the war. Mr. Misra, First Assistant, was on privilege leave from 24th May until the close of the year under review. Mr. C. C. Ghosh was granted a personal scale of pay of Rs. 200—5—250. Mr. D. Nowroji was on privilege leave from 25th October to 20th November 1915. G. D. Ojha and D. P. Singh, Fieldmen, were employed in the Central Provinces, from the commencement of the year to 9th October and from August to November respectively, in connection with the outbreak of "Maho" (*Nephotettix bipunctatus*).

At the close of the year, volunteers were called for for Fly Control work with the Expeditionary Forces in Mesopotamia. T. V. Subramania, Typist, and P. Narayanan, Artist, of this Section, together with D. P. Singh, Fieldman, on the staff of the Imperial Pathological Entomologist but actually employed in Entomological Section, volunteered and were selected and sent. A quantity of apparatus and four sprayers were also sent to Mesopotamia in compliance with indents received from the Army Department.

II. Tours.

The Imperial Entomologist was on tour in Madras from 18th August to 4th September 1915, in Coorg from 10th October to 23rd November, in the Central Provinces from 14th to 22nd March 1916, and in the North-West Frontier Province from 16th April to 20th June, a total absence from headquarters of 139 days.

Mr. C. S. Misra, First Assistant, visited the Central Provinces and Berar from 3rd to 26th October 1915 in connection with the outbreak of "Maho" (*Nephotettix bipunctatus*) and to study sugarcane pests.

Mr. C. C. Ghosh visited Ranchi from 9th to 15th September 1915 to investigate a stem-gall disease of rice plants caused by *Pachydiplosis oryzæ*, Wood-Mason.

Mr. M. N. De, Sericultural Assistant, toured in Bengal, to see the Silk Centres, from 11th to 21st July 1915.

The Fieldmen were sent on tour as occasion required throughout the year, chiefly in connection with outbreaks of pests. H. H. Prasad, Sericultural Fieldman, with two spinners and three rearers, was sent to the Madras Peoples Park Fair in December 1915, to show a complete working exhibit of Sericulture from egg to cloth.

III. Training.

Two students from the Punjab were under training in Entomology from the commencement of the year under review to 31st March 1916. Two students were also received for the course commencing on 1st June 1916 and remain under training; of these one was sent by Patiala State, the other is a private student. Mr. Mehdi Hasan, of Hyderabad (Deccan), worked in the Laboratory, from 23rd August 1915 to 27th January 1916, mostly on ants. The short courses in Lac-culture attracted no students during the year; this is probably due, as noted in last year's report, to the publication of a popular Bulletin on Lac-work. In Sericulture three students completed short courses in Eri and Mulberry Silk and three remained under training at the close of the year.

IV. Insect Pests.

The following list shows, under the heading of a few main crops, the more important investigations carried out during the year on various insect pests of crops. Other work is shown under other headings (Life-histories, etc.),

but it is not possible, in a brief report of this nature, to mention, even by name, all the insects dealt with during the year :—

1. Cotton. Experiments, commenced last year, were continued to test the relative immunity to bollworm attack of different varieties of cotton from the United Provinces, the Punjab, Bombay, the Central Provinces, and Madras. With this object in view, two sowings of each variety were made, one planted thickly and the other thinly, and weekly counts of affected bolls have been made separately for each series. The parasites that emerged were counted, recorded, and liberated; their hibernation and alternative hosts were also studied. One unexpected discovery was that there are apparently at least five different species of *Rhogas* which attack cotton bollworms (*Earias fabia* and *E. insulana*); their discrimination may prove to be of practical importance in control of bollworm by means of its parasites. The life-history of *Earias fabia* was worked out and repeated; it will be repeated again for the different seasons of the year. The seasonal colour variation of bollworm moths was also studied and a long series of specimens retained showing range of variation. Studies were also made of the utility of trap crops in connection with control of bollworm. The advantage of sowing cotton as a mixed crop was also studied and these experiments will be continued and the results written up as requisite.

At the end of May 1915, the Director of Agriculture, Punjab, requested the despatch to Hansi of bollworm parasites in order to establish a breeding plot and so facilitate their distribution in the Punjab. Between 7th June and 22nd July 1915, 158 grubs and pupæ of *Rhogas* spp. were despatched from Pusa to Hansi, and after the latter date sendings were discontinued as the parasites were fully established in the experimental plots at Hansi.

2. Rice. A diseased condition of growing rice plants, by which the whole growing stem is converted into a long, white, hollow gall, has long been supposed to be due to

attack by a Cecidomyiad fly, but little was really known about it, although a loss of thirty per cent. or more of the crop sometimes occurs. An outbreak of this disease being reported from Ranchi in September 1915, opportunity was taken to study it and it was found that the gall-formation is caused by a small fly (*Pachydiplosis oryzæ*, Wood-Mason) whose life-history was worked out in some detail, but further observations and experiments are required before the recommendation of control measures on a field scale.

Jassid bugs, locally known as "Maho," under which name are included *Nephotettix bipunctatus*, *N. apicalis* and (in less numbers) other similar species, have become a serious pest of paddy in the Central Provinces during the past two years. To help in investigation and control of this outbreak one Fieldman was lent from Pusa for the period April-October 1915 and a second Fieldman in August-November. Mr. Misra, First Assistant, also visited the affected areas in October to investigate the pest, note the damage done, and assist in control work.

Considerable attention has also been paid to these species of *Nephotettix* at Pusa, as regards their exact life-history, hibernation and alternative food-plants, but so far very little light has been thrown on these points. Numerous attempts to breed *Nephotettix bipunctatus* from the egg in captivity have been uniformly unsuccessful. Grass lands and areas which were under rice last season were frequently bagged and a powerful light-trap was also placed in these areas but, from the beginning of December 1915 up to 26th June 1916, not a single specimen of *Nephotettix* could be found, the first example being found amongst grass on 27th June 1916. There is therefore at present an interval of some seven months in the year, during which we know nothing of the life-history of this insect. Work is being continued.

Specimens of Fulgorid bugs, also found on rice in the Central Provinces, have been identified by Mr. W. L. Distant as *Sogata pusana*, *S. pallescens* and *S. distincta*.

Mealy-bugs on rice at Balasore have been identified by Mr. E. Ernest Green as *Ripersia sacchari niger.*

3. Sugarcane. The work of rearing cane-borers was continued, fresh affected cane, maize, juar, millets, wild grasses, etc., being collected and the borers and their parasites reared out. Several broods of moths, bred from known parents themselves reared in both cane and juar, were also reared to ascertain the variability of certain characters. As material accumulates it seems to become increasingly evident that the cane-borers are two or more species of *Diatræa*, which may occasionally attack juar, maize, etc., and that the normal borer in these cereal crops is *Chilo simplex* which is rarely found in cane. Further collection and study are required of material from all parts of India as the question of identity is of importance as regards control.

From observations made at Tharsa Farm, in the Central Provinces, it seems that there is some possibility of reducing the incidence of borers (in this case principally *Schœnobius*) by varying the time of planting the cane. With this view a small experimental plot of half an acre under both thick and thin varieties of cane was planted by the end of October 1915.

Two Fieldmen were detailed to assist the farm in selection of cane setts for planting in February and March.

Observations on *Pyrilla aberrans* were written up and submitted for publication as a Memoir (now in the press).

The sugarcane Aleyrodid (*Aleurolobus barodensis*) was reported from Tharsa as doing considerable damage to canes in the experimental plots. Measures for control were suggested and a large amount of material was also collected and reared to find out whether any effective parasite was present; but no parasite of any importance was obtained.

Papua depressella has hitherto been noted as boring principally in the roots of cane, being mostly in evidence in the ratoon crop. This year it exhibited a new habit by attacking new shoots of newly-planted cane in the early

part of the hot weather (April-May), causing greater damage than either *Diatræa* or *Scirpophaga*. The external symptom of attack is "dead-heart" as is the case of boring by *Diatræa, Scirpophaga* and *Sesamia*.

A series of experiments was carried out on the protection of cane setts from attack of termites, the following substances being tried, *viz.*—Lead Arsenate, Resin Compound, Fish-oil Soap with Resin, Crude Oil Emulsion, and Naphthaline Emulsion. Of these Lead Arsenate proved to be the best. In this connection it may be observed that it is not only the setts themselves which require protection but also the new shoots—in fact, in most cases the shoots are most attacked, being eaten into at the point of exit from the sett. It is of course much more difficult to protect these shoots than the setts and, to achieve this, additional treatment is usually necessary. Further experiments will be undertaken on this line next season.

4. Indigo. During the year two Indigo Pests (Indigo Aphid and *Dichomeris ianthes*) were reported from two factories, Barh Chakia and Tateriah, both in North Bihar. A Fieldman was sent to spray the infested fields with Soap Solution. Two sprayings were given and the effect was reported to be good by the Managers of the factories concerned.

5. Coffee. The year 1915 was marked by a very bad outbreak of Coffee Borer (*Xylotrechus quadripes*) in Coorg. One group of estates in S. Coorg, of about 500 acres, removed approximately 100,000 bored bushes between 1st June and 31st October 1915. The Imperial Entomologist toured in Coorg in October and November to investigate this insect. The beetles began to emerge in the last week of October and were common by the first week of November. Eggs were obtained and hatched out and it was proved that sunshine is not essential to the hatching of the eggs, as stated by former observers. The eggs, which are white, soft, of rather indeterminate shape rather like minute rice-grains, are thrust singly or in little groups (of about 6-8)

inside cracks and under scales of bark of coffee bushes; they are rarely visible, and very rarely laid externally. Experiments were started to ascertain the length of life-cycle, as it has been uncertain whether there are one or two broods in the year. Results will be written up when further information on these experiments comes to hand.

Information was also collected on pests of *Erythrina lithosperma*, which is extensively grown for shade and green-manure on Coffee Estates.

6. Orchard and Garden Pests. A special study has been made during the last three years of Insect Pests of cultivated Fruits, Vegetables and Flowers, and a considerable amount of information has been collected on the insects concerned, their identity, life-history, foodplants, occurrence and control. This information will, it is hoped, be issued shortly as a Bulletin.

Special attention has also been paid to the collection of Fruitflies. A large collection of these was sent to Professor Mario Bezzi, of Turin, last year but was apparently lost in the S.S. "Persia" on return after identification; fortunately, the types of eight new species had been sent direct to the British Museum by Prof. Bezzi. *Myiopardalis pardalina*, the "Baluchistan Melon Fly," was reared at Pusa from fruits of *Cucumis trigonus;* it was not hitherto known to occur except in North-Western India.

An important find during the year was the European Olive Fly (*Dacus oleae*) in wild olives in the North-West Frontier Province. Its occurrence in India was hitherto unknown and it is likely to be of importance in view of the attempts now being made to introduce the cultivation of the European olive in North-West India and Kashmir.

7. Life-histories of Insects. In the Insectary were reared about 200 species of insects which had not been reared before. These included about fifty Coleoptera, of various families, of which there was no previous information regarding their breeding-places and habits. Many interesting facts have been noted in this connection; for example, one Elaterid beetle grub (*Agrypnus* sp.) has now

been living in the Insectary for twenty-one months, its food consisting of Scarabæid and other beetle grubs with similar habits of working under the surface of the soil, most of them damaging roots of plants.

As mentioned in last year's report, *Bruchus affinis* was observed to lay eggs extensively on pea-pods at Pusa in January and February, so that the peas may be infected in the field before being stored. The habits of this beetle have since been investigated more thoroughly. The grubs are brought into the store inside the seeds which are externally quite sound at harvest-time, about the end of January. The beetles begin to emerge from the seeds in August, but they do not become active until about December or January, the majority of the beetles remaining inside the seeds and thus having a chance of being taken back to the field at sowing-time. Seeds from pods on which eggs were laid suffered to the extent of about 50 per cent. of the crop, whilst the remainder of this same crop (after separation of those pods with visible eggs) suffered a damage of only 3-5 per cent., and this was probably due to a small percentage of eggs being passed over. Treatment with Carbon Bisulphide or Naphthaline successfully prevented damage to the peas in store. A simple treatment (immersion of the seeds in water, when those attacked float and the unattacked seeds sink) has been found efficient for separation of the affected from the unaffected seeds and therefore it is possible to avoid liberation of the beetles in the field at the sowing time.

Bruchus chinensis breeds throughout the year in Pulse seeds in store. This insect has been observed to breed in Gram, Mung (*Phaseolus mungo*), Urid (*P. radiatus*), Bakla (*P. aconitifolius*), Kulthi (*Dolichos biflorus*), Lentil, Khesari (*Lathyrus sativus*), Arhar (*Cajanus indicus*), Bora (*Vigna catjang*), and large and medium peas. A small variety of local indigenous pea has been found to be immune from its attack. Eggs are laid on this variety as on others, but the grubs cannot bore or feed in this pea, which is, however, more liable to attack by *Bruchus affinis* in the field.

The work of breeding *Agrotis ypsilon*, referred to in last year's report, was continued in order to find out how it passes through the Hot Weather and Rains (April-September). In the Insectary it continued to breed throughout this period. The moths, however, which emerged in July-August did not lay fertile eggs although they had full chances of mating; possibly this was due to inbreeding under unfavourable conditions; at any rate, fertile eggs were not obtained. But, as it was, the insect bred in captivity until about the time (August) when the moths normally appear in the *tal* lands which are subject to attack at Mokameh. During 1916 an Andres-Maire trap was worked in the Insectary compound at Pusa throughout the hot weather (April-June) to see whether any moths of *Agrotis ypsilon* could be attracted but not a single example was captured. What actually happens under normal conditions remains, therefore, still a mystery. The insect can continue to breed under favourable conditions but we have no evidence that it actually does so: our Insectary experience has yielded no indication of any inclination to pass through the hot weather in any resting stage; on the contrary, breeding was continuous until August. On the other hand no trace of the insect has been found under natural conditions between April and August. The migration theory fits the known facts but as yet remains an unproved hypothesis.

Colonies of *Odontotermes assmuthi*, established in artificial breeding cages (tiles) in the Insectary, died out after about four months, by which time adult workers and soldiers had been obtained. One colony, however, which had been planted out in a cage in the ground in the Insectary compound, could be traced for a whole year, after which it dwindled away; even after this period, however, the queen showed no particular sign of a dilated abdomen.

The habits of *Metriona circumdata*, *Aspidomorpha indica* and *Philemostoma trilineata* were observed throughout the year. The beetles hibernate and live for about six months.

The life-history of *Ancylolomia chrysographella* was also traced throughout the cold weather (November-February). This moth hibernates in the larval stage and breeds continuously in the hot weather.

Two tube-forming Tineid larvæ, *Melasina* sp. and *Myrmecozela leontina*, both with only one brood in the year, were also under observation.

The life-history of *Leucophlebia lineata* (Sphingidæ) was traced throughout the year. The larvæ were noted to hibernate as well as æstivate.

Oides bipunctata (Chrysomelidæ) has been observed to hibernate and æstivate in the egg stage.

Polytela gloriosæ (Noctuidæ) has been observed to hibernate and æstivate in the pupal stage.

The already known habit of larval æstivation in *Mudaria cornifrons* (Noctuidœ) was confirmed by further observations.

In connection with other experiments on *Bactrocera cucurbitæ* (Trypaneidæ) it was noted that this Fruit-fly is capable of living in confinement in the adult state for a period of over three months. Under natural conditions it seems probable that many Fruit-flies live over from season to season in the adult state. It was also noted that stems of Cucurbitaceous plants and galls thereon, caused by Cecidomyiadæ or otherwise, were as favourable breeding-places for these flies as the fruits themselves.

In addition to the foregoing, complete cycles were observed of *Danais plexippus* (on *Oxystelona esculentum*, a new food-plant), *Kolla mimica* on paddy, a Jassid bug on sugarcane leaves, another Jassid on leaves of *Cyperus rotunda* (*Mutha*), *Polia consanguis*, a Halticid beetle on *Anisomeles ovata*, and *Cyrtacanthacris ranacea*.

A few broods from known parents were reared of *Terias hecabe* and *Papilio polytes* to ascertain proportional variation.

Further observations were made on the habits of *Tenebroides mauritanicus*, *Odoiporus longicollis*, *Attagenus*

piceus, *Lepisma* sp., *Chilo simplex*, *Laspeyresia pseudonectis* and many other insects. Special attention was paid to leaf-mining Lepidoptera and numerous species, including many hitherto undescribed novelties, were bred out from crops and other plants.

Unsuccessful attempts were made to breed *Nephotettix bipunctatus*, *Zonabris pustulata*, *Lytta actæon*, and *Heliocopris bucephalus*.

Large numbers of Fruit-flies were reared out to discover to what extent they are checked by parasites but it was found that the proportion of parasites is extremely low. The only Fruit-fly which is parasitized to any appreciable extent is *Carpomyia vesuviana*, whose larvæ feed in fruits of *Zizyphus jujuba*. About 800 pupæ of this fly were sent to Italy, to endeavour to introduce the parasite there, but owing to postal delays they failed to reach their destination alive.

8. Insecticides. A series of experiments was carried out to test the effect of poisoned sprays on Fruit-flies, the species used being *Bactrocera cucurbitæ*. It was found that a spray of *gur* (sugar) and Lead Arsenate killed the flies in the course of about 36 hours. A similar mixture, of *gur* and Lead Chromate, had practically no effect and proved quite useless as a poison.

9. Protection of Timber against Termites. The trials under this heading were continued. Further tests of Powellized wood and of Microlineum were made. Preliminary tests of Sideroleum were made, further tests being held in abeyance pending receipt of more material promised by the Agents of this preparation. Tests of Timborite were put in hand.

10. Grain storage experiments. The storage of wheat, rice and pulses, commenced last year, has been undertaken this year on a larger scale based on the first year's results. In addition, in order to determine the pests of stored products more exactly, over sixty different substances have been placed under ordinary storage conditions for observation of their insect pests.

As a result of the first year's experiments, the lime treatment of rice has been found most satisfactory, the stored rice being rendered practically immune from all pests without impairing the edible qualities. It must, however, be noted that the preliminary experiment was done on a very small scale and further tests on a larger scale are now in hand to check this result. The same remark applies to several other samples of wheat and pulses treated in different ways, and all are being retested on a larger scale. One curious case may, however, be mentioned here as at present it seems rather inexplicable; a jar of wheat grains infested with *Calandra oryzæ* had about half an inch in depth of dry sand spread evenly in a layer over the top of the wheat; in due course the weevils emerged and made their way up through the sand which, however, they seemed unable to penetrate again, and all the adult weevils died and formed a layer on top of the sand, leaving the underlying wheat grains unaffected by any further weevils. At first sight it seemed that the experiment had been successful and that a simple layer of dry sand would form an efficient protection for wheat stored either for sowing or for food; but, on testing, this wheat failed to germinate. It was closed up in a glass jar : but so were other samples, equally, more, and less affected by weevils, and kept in exactly similar jars; yet these other samples germinated successfully.

V. Bees, Lac and Silk.

1. Bees. Experiments with *Apis indica* were continued. The Wax Moth (*Galleria mellonella*) gained entrance to the hives at an unexpected period (December) and destroyed five out of seven colonies; other colonies were procured but these were a little too late for the honey flow.

One colony of *Apis indica* was specially worked (1) to check swarming and (2) to attain the maximum yield of honey. Swarming was checked successfully and the yield of surplus honey was 15½ lb. *i.e.*, about double the ordinary quantity. The result was attained by improved methods

and an adequate supply of ready-made combs at the proper time. Work on these lines will be continued.

Several requests for Frame hives, Comb Foundation and other Bee-keeping requisites, from various inquirers, have been met as far as possible.

No further experiments have been made with European Bees owing to the great danger of introduction of Isle-of-Wight Disease into India. In this connection a word of warning may well be issued to any would-be importers of European bees.

A Bengali Bulletin on Bee-keeping has been written up and will be sent in for publication at an early date.

2. Lac. The emergence of Lac larvæ took place at Pusa on 30th September 1915 and 12th June 1916, and sixty large *Ber* trees were inoculated.

Three Lac Show-cases were sent to the Chandernagore Exhibition, in December 1915, together with copies of the Lac Bulletin (in English and Hindi) for distribution to interested inquirers.

A demonstration in Lac-culture was given to the students from the Sabour Agricultural College who visited the Institute.

No students attended the short courses in Lac-culture.

Numerous inquiries for Brood-lac, etc., were dealt with during the year.

3. Silk. Three students completed short courses in Eri and Mulberry Silk-work and three remained under training at the close of the year. Eri silkworm eggs were distributed to 89 applicants and Mulberry silkworm eggs to 70 applicants. Eri eggs and castor seed were sent to the Agricultural Department in Mauritius, where they arrived safely and have done well. Mulberry and Castor seeds, Mulberry cuttings and samples of different kinds of silk were distributed to numerous inquirers. Instructions for rearing, reeling, dyeing, bleaching, and spinning were given by correspondence. The Univoltine Mulberry silkworm eggs which were sent to Shillong and Muktesar for cold

storage gave satisfactory results on rearing in March, but those sent to Guindy for rearing in October were not successful. Some of the hybrid multivoltine races, which have been under selective rearing during the last four years, were reared on a large scale and gave satisfactory results, the outturn of reeled silk in all cases being superior to pure multivoltine races but inferior to univoltines. Silk Exhibits were sent to the Agricultural Show at Muzaffarpur and to the Exhibitions held at Chandernagore and Madras; a complete working exhibit, showing the whole process of sericulture from the egg to the finished cloth, was sent to the Madras Exhibition and proved a considerable attraction. A rearer was lent to Rewah State to demonstrate Mulberry silkworm rearing and reeling. The services of Harihar Prasad, Silk Fieldman, were placed at the disposal of the Imperial Agricultural Bacteriologist in connection with his work on investigation of Pebrine in Mulberry Silkworms.

A Bengali translation of Bulletin No. 48 (First Report on Mulberry Silk Experiments) was printed during the year, and a second edition of Bulletin No. 39 (Instructions for rearing Mulberry Silkworms) is now in the press. A Second Report on the Mulberry Silk Experiments has been written up. Articles on Mulberry Silk were also contributed to the Bengal Journal " Grihastha."

Visitors to the Silk House included Miss M. L. Cleghorn (on special silk duty under the Government of Bengal), Mr. De Minville, and Mr. H. Maxwell-Lefroy, Imperial Silk Specialist.

Silk pieces, to the value of Rs. 504-13-0, were sold during the year and the proceeds credited to Government.

Some experiments were carried out with *Tricolyga sorbillans*, Wied. (*bombycis*), the Tachinid parasite of silkworms, in connection with its method of oviposition and breeding-habits. The following caterpillars were exposed to attacks of the flies, *viz.*:—Mulberry silkworms (*Bombyx mori*), Eri silkworms (*Attacus ricini*), *Achæa janata*, *Spodoptera mauritia*, *Polytela gloriosæ*, *Cosmophila sabulifera*, *Papilio demoleus*, *Utetheisa pulchella*, and

Diacrisia obliqua, of which the last two are hairy and the others smooth-skinned. The flies were found to oviposit on all the varieties of caterpillars, whether hairy or smooth, but could not breed in other caterpillars so successfully as they could in the silkworms. Flies were actually bred out only from the parasitized larvæ of *Cosmophila sabulifera* but from the experiments it appeared that the flies could, if necessary, breed in the other caterpillars.

VI. Illustrations.

Coloured plates illustrating the life-histories of the following insects were prepared during the year, *viz.*:— *Pachydiplosis oryzæ*,* *Papua depressella*, *Phyllocnistis citrella*, *Chloridea assulta*,* *Kolla mimica*, *Oedematopoda clerodendronella*, *Epicephala chalybacma*, *Terias hecabe*,* of which those marked * are now in press and will be available shortly.

A coloured plate of orange fruits was also prepared for the Agricultural Officer, North-West Frontier Province. Besides the completed coloured plates, a large number of figures, in colour and line, was drawn of various insects and these will be utilized for publications in due course.

There is always a heavy pressure of work to be done by the Artist Staff and our life-history work is constantly handicapped by insufficient artistic assistance.

A list of all the coloured plates of Indian insects, prepared to date, was issued during the year, mainly for the information of Provincial Entomological Staffs. This list shows for each insect whether the coloured plate has been printed and, if published, in what publications it has appeared.

The issue of coloured plates and lantern slides has been continued.

VII. Miscellaneous.

Correspondence. A total of 95 parcels of specimens, mostly of crop-pests, was received during the year for identification and advice, whilst 1,090 letters were received

and 1,422 issued, but all these numbers are exclusive of a large amount of routine correspondence. As the activities of the Section become better known, the correspondence becomes more and more onerous and takes up more time which should be devoted to more productive work.

VIII. Insect Survey.

Steady progress has been made in additions to, and arrangement of, the collection. The whole of the collection of Lepidoptera has been overhauled, rearranged and placed in one series, so that all the information on any species or group is now available in one place. The same is being done with the Coleoptera, which are nearly finished, and other groups will be taken up as time and staff permit. Work of this sort takes time and care, but is necessary as, in the not infrequent case of non-identification or misidentification of an insect at the time of its collection or occurrence as a pest, the specimen itself forms the only evidence of its identity and if it is hidden away, out of the series, as a " duplicate " or " non-identifiable," valuable information may easily be overlooked.

The collections continue in good order but the difficulty of maintaining them, in boxes in open racks in a climate such as that of Pusa, is very great.

The following collections were sent out to Specialists in the groups named and our thanks are due to them for the help afforded :—

(*i*) Micro-Lepidoptera to Mr. E. Meyrick, F.R.S., to whom special thanks are due for his examination of the whole of our unnamed material, of which about forty per cent. proved to be new to Science. The novelties are under description in " Exotic Microlepidoptera." A Memoir on life-histories of Indian Microlepidoptera, comprising all the information published hitherto together with a mass of new material now rendered available by the identifications received, is now in preparation.

(*ii*) Rhynchota to Mr. W. L. Distant. Much of the new material has been utilized in Volume VI of *Rhynchota*, lately published in the "Fauna of British India" series. Some of our material has been received back.

(*iii*) Rutelidæ to Mr. G. J. Arrow, who will use this material for his "Fauna" volume on this group. Specimens returned, named.

(*iv*) Carabidæ to Mr. H. E. Andrewes, who is working on the Indian species of this group. Partly returned, named.

(*v*) Trypaneidæ to Professor Mario Bezzi of Turin. The specimens were named and we were advised of their return, but they have not been received and were presumably lost in the S.S. "Persia." Types of eight new species had fortunately been sent direct to the British Museum by Professor Bezzi.

(*vi*) Parasites of Trypaneidæ to Professor Silvestri, Portici, Italy. Not yet returned.

(*vii*) A Dryinid parasite on nymphs of *Pyrilla* spp. to Mr. J. C. Crawford. Named as *Chlorodryinus pallidus*, Crawf.

(*viii*) Cecidomyiadæ to Professor E. P. Felt. They have been named and the collection retained for the present.

(*ix*) Sphegidæ to Mr. Rowland Turner. Not yet received back.

(*x*) Apidæ to Mr. G. Meade-Waldo, whose recent untimely death has deprived us of a most valued correspondent who was always willing to give us every help in identification of our specimens. This collection remains at the British Museum and will probably be transferred to Professor Cockerell for examination.

(*xi*) Curculionidæ to Mr. G. A. K. Marshall. Partly named and returned.

(*xii*) Cerambycidæ to Mr. C. J. Gahan. Not yet returned.

(*xiii*) Histeridæ to Mr. Lewis. Not yet returned.

(*xiv*) Coccidæ to Mr. E. Ernest Green. Partly named and returned.

(*xv*) Diptera (various groups) to Mr. E. Brunetti, who has taken much time and trouble in affording us help.

(*xvi*) Towards the close of the year the manuscript of a paper descriptive of a collection of Indian Termites, sent in 1912-13, was received from Professor Nils Holmgren, of Stockholm. This paper is written in German and will require translation before publication. It contains descriptions of numerous new species and the issue of these will enable a mass of notes on these species to be written up for publication.

(*xvii*) Examples of *Stibaropus minor*, Wlk., found in an Ant's nest were sent to Mr. Donisthorpe, who, however, considered that they were not myrmecophilous insects.

(*xviii*) A collection of *Rhogas* spp. was sent to Mr. C. T. Brues, United States of America, for identification and description of the new species.

(*xix*) A mite found attacking the cocoons of a Burmese Ant, *Ectatomma coxale*, was sent for examination by Mr. S. Hirst, who writes that it is a new species of the genus *Urodinychus*, Berlese. Some species of this genus are known from Europe, a few from Africa and one from Java, and of these some have been found in ants' nests but very little is known about their habits.

Various collections of Indian insects have been received and named and returned as far as possible; these included (*i*) a collection of Rhynchota from Mrs. Kilby, (*ii*) Microlepidoptera from Coimbatore Agricultural College, (*iii*)

insects from birds' stomachs sent by the Nagpur Museum, (*iv*) various insects from Nagpur Agricultural College, (*v*) various insects from Entomological Assistant, Burma, (*vi*) collections of Hymenoptera, Lepidoptera, and Rhynchota from Mr. C. Inglis, besides numerous other small sendings.

IX. Programme of work for 1916-17.

Major.

This will follow generally on the lines of work of the current year and will include general investigations of crop pests and especially of the pests of rice, sugarcane and cotton, of fruit-trees and of stored grain.

Minor.

A commencement has been made of collection of information for a general book on the crop pests of India and progress in this will be continued, as also in the publication of information regarding life-histories of pests and coloured plates, of which a large number are now ready for printing. Work and experiments in silk, lac and bee-keeping will be continued, and new insecticides and insecticidal methods tested as occasion arises. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

X. Publications.

The following publications have been actually issued during the year :—

De, M. N. . . .	Instructions for rearing Mulberry Silkworms. [*Bulletin 39 (Revised Edition), Agricultural Research Institute, Pusa.*]
Fletcher, T. Bainbrigge.	Bees and the Fertilization of Coffee. (*Bulletin 69, Madras Department of Agriculture.*)
Fletcher, T. Bainbrigge.	One Hundred Notes on Indian Insects. (*Bulletin 59, Agricultural Research Institute, Pusa.*)

Fletcher, T. Bainbrigge. Report on Agricultural Entomology, 1914-15. (*Board of Scientific Advice Annual Report.*)

Misra, C. S. . . Report on Investigations regarding the Maho (*Nephotettix bipunctatus* and *N. apicalis*) in the Central Provinces, October 1915. (*Central Provinces Department of Agriculture.*)

REPORT OF THE IMPERIAL PATHOLOGICAL ENTOMOLOGIST.

(T. Bainbrigge Fletcher, F.L.S., F.E.S., F.Z.S.)

I. Charge and establishment.

Mr. F. M. Howlett, B.A., F.E.S., Imperial Pathological Entomologist, was in charge of the section from 1st July to 28th July 1915, after which he proceeded on six months' combined leave, afterwards commuted into leave on medical certificate and extended by a further period of six months. Mr. B. Coventry, C.I.E., Agricultural Adviser and Director, was in charge from 29th July to 8th August, and the Imperial Entomologist was in charge of the work, in addition to his own duties, from 9th August to the close of the year (30th June 1916).

Mr. P. G. Patel was absent on privilege leave from 3rd to 22nd January 1916, Mr. H. N. Sharma from 8th to 20th December 1915, and Mr. S. K. Sen, from 25th October to 4th December 1915.

In response to a call for volunteers for Fly Control work with the Expeditionary Forces in Mesopotamia, Messrs. Patel and Sharma volunteered their services at the close of the year and have since proceeded.

Tours. Mr. P. G. Patel visited Kathgodam and Bareilly from 12th September to 23rd December to collect and study biting flies in connection with the Imperial Bacteriologist's experiments on Surra transmission.

Mr. S. K. Sen toured in Madras and Bengal from 21st July to 12th September 1915.

Correspondence. The number of letters received and issued during the year amounted to 211 and 228 respectively, whilst 151 parcels of specimens were also received and dealt with. Most of these parcels were of maggots causing myiasis in domestic animals, but several lots of mosquitos, ticks, etc., received for identification, were dealt with.

II. Work done. Disease-carrying insects.

Cattle Flies.

Observations were continued on the life-histories of various Tabanidæ occurring at Pusa. As regards the feeding-habits of Tabanid larvæ it was noted that cannibalism is not universal; at least, so far as observed, larvæ of *Tabanus nemocallosus* do not attack and destroy one another. Forty nearly full-grown larvæ of this species were collected and confined in a very small glass vessel, with some moist earth, but actual counts made twice weekly discovered no larvæ missing or damaged. Of these larvæ, collected on 27th January, only a very few emerged as flies in March, the majority in April and May, and a few in June. The pupal period is eight or nine days. One larva kept under submerged conditions lived for over three months in water without any food; these larvæ must therefore have a respiratory system fitted for both aquatic and terrestrial life and can exist over a considerable period if conditions are unfavourable. Egg-masses of *T. nemocallosus* were found fairly commonly from the third week in April; this species appears to be rather gregarious in its egg-laying habits, depositing its egg-masses by preference on *Phragmites*. The newly hatched larvæ are also gregarious in habit, often noted to be crowded up in a mass in one place in the breeding vessel. Grown larvæ are also more or less gregarious, as on one occasion 63 grown larvæ were collected in one small area of about two square yards, such density of population being only possible if a non-cannibalistic habit is usual. As regards the feeding habits of the adult flies of *Tabanus nemocallosus* it was found that when bred females, starved under humid conditions for twenty-four hours after emergence from pupa, were allowed to bite, under cover of a test-tube, a goat whose skin had been shaven and moistened a little before they were placed to feed, all of them were observed to suck blood within five minutes; in the case of other Tabanids, various observers

have commented on the difficulty in inducing bred females to suck blood (see Patton & Cragg, *Text-book of Medical Entomology*, page 295).

Tabanus albimedius. Flies emerge about the end of February. Egg-masses of this species were observed along the river bank by the middle of March. Egg-laying is at its height thence onwards until the middle of April, whilst very few egg-masses could be found after the beginning of May. A second brood of this fly emerges about the end of June and a third brood in October, the descendants of these again appearing in February-March. These eggs are parasitized by a small chalcidid, of which 166, 78, 105 and 138 individuals emerged from four egg-masses; these parasites were bred and the life-cycle from egg to adult noted to be eight days in the case of males and nine days for females; the males, which are yellowish and smaller than the black females, thus emerge one day earlier and move about on the parasitized egg-mass in eager expectation of the emergence of the females; on this happening, coupling commences immediately and oviposition follows a few hours later. Sixty parasites were bred from one fresh egg-mass of *T. albimedius* after this had been subjected to the oviposition of one fertilized female parasite; the total number of eggs, which may be laid, may, however, be larger, as indicated by the number of parasites reared from individual egg-masses.

Egg-masses of *T. nemocallosus* were also noted to be subject to attack by a parasite of a different species, but no parasites were found in egg-masses of *T. bicallosus.*

Tabanus striatus seems to have three broods annually as in the case of *T. albimedius*, the flies emerging about the end of February, June and October.

Tabanus sanguineus, on the other hand, was not observed on the wing until the end of May, and *T. hilaris,* which is common during the Rains, also did not appear until the end of May.

Chrysops stimulans oviposits on grass growing in shallow water by a river bank during the last week in

March and during April; oviposition seems to take place only between about the hours of noon and 2 P.M. The eggs of this *Chrysops* are smaller and thinner than those of *Tabanus;* they are arranged in a single layer, forming a compact mass; the process of oviposition is almost the same as in *Tabanus.* The new-laid eggs are creamy-white, later changing to pale-brown and ultimately to fuscous; they hatch after 7 days (1-30 P.M. on 22nd March to 8 A.M. on 28th March). The larvæ, like those of *Tabanus*, wriggle out from the eggs and very soon drop into the water. The larva appears sluggish but readily shams death, by bringing together both ends of its body, even at the slightest contact of the vessel in which they were kept; this habit seems characteristic of larvæ of this genus but not of other Tabanid larvæ. The newly hatched larva is about 1 mm. long and has a white syphon-tube which as well as the last segment, is clothed with very minute hairs; all body segments, except first and last (syphon), with a pair of very small delicate bristles on lateral margin; the first body-segment has two pairs, whilst the syphon carries about three pairs apically; Gräber's organ marked by two black dots. After a week, little change is visible except that Gräber's organ is marked by two pairs of dots, posterior pair smaller. Larvæ three weeks old measured 3 mm. long by 0·7 mm. broad, and Gräber's organ had seven black dots, six paired and one single. Larvæ one month old were 5 mm. long by 0·75 mm. broad, and the whole body had developed a pattern on its surface, so that the appearance of the larvæ was quite altered; Gräber's organ had now nine black dots. The larvæ feed readily on dead earthworms and are probably cannibalistic.

Larvæ of *Gastroxides ater*, kept under observation in a small glass vessel, were not found to be cannibalistic. This species breeds in hollows in tree-trunks. The flies sometimes come into light at night (as do several species of *Tabanus*) and are perhaps nocturnal in their habit of flight.

Surra Investigation.

Mr. Patel visited Kathgodam and Bareilly in September-December 1915, to ascertain what kinds of biting flies were prevalent in the Surra Zone and to carry out transmission experiments. A full account of these has been sent to the Imperial Bacteriologist, who will (I understand) publish them with his own results; it is therefore only necessary to give here a short summary of the results attained, *viz.*:—

(1) *Tabanus albimedius* and *T. striatus* were found capable of transmitting the Surra organism, not only by an interrupted feeding, but also by complete feeding.

(2) *Tabanus albimedius* was proved to transmit Surra 24 hours after feeding on Surra-infected animal; it failed to transmit disease after a longer interval. *T. striatus*, however, was found capable of transmitting Surra (in one experiment with two flies) as long as 72 hours after feeding on an infected host.

(3) Smaller species of Tabanus (*T. sp.* near *virgo*) were tried but not found to transmit disease.

(4) *Ctenocephalus felis*, dog and cattle fleas, were found incapable of transmitting Surra.

(5) *Philœmatomyia insignis* is only capable of transmitting Surra in the case of an immediate interrupted feeding, the maximum interval (*i.e.*, between leaving an infected host and commencing to feed on a previously uninfected animal), for which positive results were obtained, being only seven minutes, although positive results were obtained by direct inoculation of abdominal contents of infected flies as long as 28 hours after feeding on a Surra-infested animal.

(6) Surra is not transmitted hereditarily to the progeny of infected females of *Tabanus striatus*, *T. albimedius*, or *Philœmatomyia insignis*

Mosquitos.

The Mosquito Campaign was continued on the Pusa Estate with considerable success, the reduction in numbers of mosquitos prevalent during the year being in marked contrast to the experience of previous years. Breeding-places were sought out and dealt with, either by filling in (hollows in trees, small puddles, etc.), removal (tin cans, pots, etc., holding rain-water), oiling (large semi-permanent pools) or the introduction of larvivorous fish (more or less permanent pools, wells, etc.). Pieces of bamboo-stem, filled with water, were also placed out in trees and in other likely situations to serve as traps for oviposition of *Stegomyia*, and regularly emptied out and replaced. The following were the principal species found breeding on the Estate during the year, *viz.*, *Anopheles fuliginosus*, *A. culicifacies*, *A. rossi*, *Culex fatigans*, *C. gelidus*, *C. sitiens*, Wied (*microannulatus*, Theo), *Tæniorhynchus tenax*, *Stegomyia scutellaris*, *S. sugens* and *S. gubernatoris*. *Pseudograbhamia maculata*, not previously noted at Pusa, was also found and reared during the progress of this work.

Eleven coloured plates, showing life-histories of mosquitos, were sent to press during the year and will be available shortly, and other plates were completed.

Mr. S. K. Sen carried out a series of experiments on the rôle of blood in the development of eggs in mosquitos, the species dealt with being *Stegomyia scutellaris* for the most part. This inquiry was still in progress at the close of the year but a preliminary report on the results attained has been written up; meanwhile, it may be noted here that, as regards *S. scutellaris*, it has been found that this species (1) may oviposit without having fed on blood, (2) may deposit as many as three batches of eggs after only one meal of blood, (3) a single fertilization will suffice for several batches of eggs.

The collection of mosquitos was rearranged and put in order during the year.

A small collection of mosquitos from Pachmarhi was named up and returned and several other small lots of mosquitos were received and identified during the year.

Flesh-Flies.

In response to a circular to Veterinary officers, a large number of specimens of maggots, causing myiasis in domestic animals, etc., have been received and the flies bred out. A parallel series of observations has been kept up on the attractiveness for various flies, especially those species breeding in septic matter, of meat treated in various ways; the substances tried included Peptone, Hydrochloric Acid, Formalin, Papain with Hydrochloric Acid, Borneol, Vanillin, Sugar, Salt, Mercurous Chloride, Benzine, Lactic Acid.

Ticks.

Specimens of *Ornithodoros savignyi*, received from Madras in 1914, and some more of the same species from Gujarat, were under observation throughout the year. A species, identical with or near *O. lahorensis*, was received from Agra. Both were fed on goats.

III. Programme of work for 1916-17.

The work which can be done will depend on the return of (1) Mr. Howlett, now on extended leave on Medical Certificate up to 28th January 1917, (2) the two Assistants sent to Mesopotamia for Fly Control work. Pending their return work must be largely of a routine character, *viz.*, care and upkeep of collections and records, breeding and observation of Tabanids, Mosquitos, Ticks, etc., continuance of Mosquito Campaign, and affording help to inquirers as far as possible.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

(C. M. HUTCHINSON, B.A.)

I. ADMINISTRATION AND TOURS.

Charge. I held charge of the section throughout the year excepting one month's privilege leave in September and October 1915, when Mr. N. V. Joshi was in charge.

Establishment. Mr. C. S. Ram Ayyer was on privilege leave for two months from 25th April 1916.

Mr. A. N. Bose went on privilege leave for one month and four days from 20th November 1915.

Mr. Hardayal Singh has left this section on deputation to work in the Agricultural Department, United Provinces, for two years, and Mr. Umrao Bahadur Mathur has been appointed in his place.

Tours. The following tours were made by me during the year 1915-16 :—

1. July 1915. To Calcutta to carry out experiments on the use of a new form of inoculation for rice beer in the laboratory of the Chemical Examiner, at the instance of the Assistant Commissioner of Excise for Bengal.
2. October 1915. To Shillong on hill recess.
3. November 1915. To Calcutta to consult Director General of Commercial Intelligence Department, on the subject of saltpetre industry, Messrs. Graham & Co., on the subject of manure supply and Messrs. D. Waldie & Co., Konnagar, on the subject of fermentation.
4. March 1916. To Muzafferpur to be present at a meeting of the Bihar Planters' Association.
5. April 1916. To Simla to consult the Imperial Silk Specialist, in connection with the pebrine disease investigation; to Muzafferpur to address

Bihar Planters' Association Meeting on the subject of the modified method of green-manuring.

6. May 1916. To Bakagaon, Dooriah, Motipur, Mehsi and Bara to inquire into the local methods of *nuniahs* in connection with the saltpetre industry.

7. June 1916. To Saraya, Bara and Peepra factories, in connection with work on Indigo manufacture.

II. Training.

Mr. D. V. Bal, Assistant to the Agricultural Chemist to the Government of Central Provinces, who was under training in this laboratory from 20th August 1914, finished his course on the 17th April 1916 and was allowed to return to his Province.

Mr. S. N. Bose, Bacteriological Assistant to the Agricultural Chemist to the Government of Bengal, is under training in this laboratory from 3rd January 1916.

III. Soil Bacteriology.

Toxins. Work on the lines indicated in the report of this section for the previous year was continued, but was considerably interfered with by the claims of special enquiries on various technical subjects hereinafter dealt with. Considerable progress, however, was made in collecting evidence as to the occurrence in field soils of toxins resulting from bacterial action, and of their unfavourable influence upon fertility as dependent upon nitrification and correlated bacterial processes in soil. A series of field experimental plots under wheat demonstrated the production of infertility in soil containing nitrogenous organic matter (oil-cake) as a consequence of semi-anaerobic conditions artificially induced by water-logging; this infertility did not occur to the same extent when ammonium sulphate was substituted for cake, nor did the effect of the water-logging become apparent until the roots of the plants had gone down some inches, to that level in the soil which

oxidation consequent on the cultivation, had failed to reach. Parallel plots with barley illustrated this effect more markedly than those with wheat, no doubt owing to the later formation of the secondary root system in the former crop and its consequent dependence for a longer period of its early growth upon the original deeper roots. Laboratory work on nitrification and on the growth of seedlings in water and soil cultures demonstrated the possibility of separating substances from certain bacterial cultures, from decomposing organic matter and from anaerobically incubated soil, whose toxicity to nitrifiers, and in greater concentration to seedling plants was demonstrable under these conditions.

Interesting observations were made as to the interference with the growth of seedlings resulting from the bacterial invasion of the unexhausted and still attached seed and the consequent absorption by the plant of toxic bacterial by-products. This invasion occurred most readily in water-logged soil and more especially in the presence of bacteria derived from anaerobically incubated soils of high organic matter content. Copper sulphate was found to neutralize most of the toxic bodies obtained in this way, and seeds treated with this salt were found to be immunized to some extent, although not entirely or invariably, against this action. It is suggested that some such treatment might be advantageous when sowing in wet soils, although the results of field trials have so far not yielded conclusive results, owing to the difficulties associated with its use and the unfavourable effect upon germination which copper sulphate has been found to exert in many instances.

Amongst soil toxins produced by bacterial action nitrites are well known to exert a prejudicial effect upon plant growth; it has been found that their presence in soils is not alone due to the reduction of nitrates already formed, although this is of frequent occurrence, but that in many of the soils examined in this laboratory nitrites accumulate to some extent before nitrate formation becomes evident, even under conditions apparently favourable to nitrification.

It is not clear at present whether this is due to the formation and reduction of nitrates or to incomplete oxidation consequent on the lack of activity or insufficient number of nitrate formers in the soil. Evidence is not wanting that in many of the soils examined the very slow rate of nitrification observed under optimal conditions of aeration and water content, is due to the absence in sufficient numbers or lack of physiological activity of the necessary nitrifying organisms. It will be readily realized what an important field for enquiry is opened up by this observation, which, however, in view of its wide divergence from received ideas on this subject, will require further substantiation by careful experiment and observation. The effect of nitrites on seedlings and the concentration required to produce the prejudicial results observed, was ascertained for various field crops in water culture. At the same time observations were made as to the concentration of nitrites occurring in the soil water under various conditions, but in none of the soils examined was this found to rise to the degree found toxic in water culture. It does not necessarily follow that this statical treatment of the question disposes of the possible intoxication by nitrites of plants growing in such soils, owing to the necessity for taking into account the constant formation of nitrites in the soil to replace those absorbed by the plant or oxidized in the soil, and the possibility of cumulative intoxication in the plant itself of which at present we know nothing. The presence of nitrites in soil was found to affect germination and early growth; this explained the apparently anomalous result of an experiment in which germination in a well-aerated soil compared unfavourably with that in the same soil badly supplied with air; on further examination it was found that in this soil when well aerated complete nitrification was preceded by the incomplete stage of nitrite formation and accumulation, and as this was coincident with the germination period of the seeds sown therein the germination of the latter was interfered with to a greater extent than in the soil in which no nitrification was taking place.

Weekly borings and nitrate determinations throughout the year were made in three sets of duplicate plots under grass, cold weather and rains crops (wheat and maize), and fallow respectively. Only in the last of these was there any accumulation of nitrate in the first foot of soil, a much smaller amount occurring in the cropped soil and only very small quantities under grass. Experiments will be made to ascertain whether the grass effect is due to interference with the upward movement of water resulting from evaporation from the surface, to lack of aeration, or possibly to the toxic action of the specific bacterial flora associated with the grass plants. The nitrate accumulation was highest in February and reached a minimum in August; this was only in the first foot of soil and no doubt represented the vertical movement of nitrates parallel with that of the soil water.

Green-manuring. Experiments with fermented green manure were carried out on tobacco to which fermented sann hemp (*Crotalaria juncea*) was applied. Very large increases in yield were obtained, and a Bulletin (No. 63) describing this modified method of manuring was published, inviting suggestions and criticisms from agricultural officers in the Provinces from whom many useful and appreciative communications have been received, pointing out the applicability of the method to various manurial problems and special cases in their several districts. It is hoped that the experimental trials of this method which are now being made throughout India may lead to more satisfactory and certain results from the use of green manures than are generally obtained. A field trial of the method at Pusa carried out by the Imperial Agriculturist on the *rabi* oat crop gave very high returns : the Officiating Imperial Agriculturist is carrying out a further experiment this year.

Saltpetre. The enquiry into the conditions favouring the occurrence of saltpetre in Indian soils and the methods adopted by the native for extracting it, was continued and the results published in a Bulletin.

It was concluded that the output of saltpetre is limited at present not so much by the available supply of raw material, as by the number of workers (*Nuniahs*) actually engaged in extraction, this being largely determined by the price of crude saltpetre and the restrictions imposed by landholders, refiners, and the Salt Department. No special soil organisms appear to be associated with saltpetre deposits which are the result of the nitrification of organic matter accumulated in the neighbourhood of human dwellings, the high concentrations of nitrate found in the soil in such sites being due to the upward movement of water carrying dissolved nitrates to the surface where they become concentrated by the intense evaporation going on during the dry months of the year. Experiments on a field scale showed the feasibility of adding to the store of nitrates in the country by the use of nitre beds made up by burying a green crop, in this case *Crotalaria juncea*, in ordinary field soil and compacting the heaps sufficiently to ensure the capillary rise of water from the subsoil to the surface, where the nitrate formed accumulates and can be scraped off after the manner of the *nuniah*. It is suggested that a very large output of saltpetre could be obtained in this way in those parts of India in which soils with sufficient lime content and suitable physical texture are found. At the same time the condition of the industry as a whole could be greatly improved by the introduction of better relations between the *nuniah* and refiner and a revision of the rules of the Salt Department in regard to both of them. It seems clear that the profits of the trade are not equitably divided between the *nuniah* and the refiner, the former class, in consequence of its poverty and lack of business capacity, being entirely at the mercy of the middleman or refiner to the detriment of the industry as a whole. So far as the methods of extraction and refining are concerned the work of the Chemical Section of this Institute, as described in Bulletin No. 24 by Messrs. Leather and Mukerji, has demonstrated the possibility of great improvement in the refining part of the process, and further investigation in

the writer's laboratory has shown that the *nuniah's* method of extraction of the crude saltpetre is far from being economically sound, and could be greatly improved upon by some simple variation of his present technique, which would, however, probably depend upon co-operation with the Salt Department in order to avoid infringement of the regulations at present in force. An advantage offered by the artificial method of producing saltpetre above referred to, lies in the comparative freedom from contamination by salt (sodium chloride) of the crude saltpetre resulting from this method, thus avoiding to a great extent in the process of extraction the restrictions necessarily imposed upon this process by excise requirements, with a consequently higher return of pure product to the advantage of the *nuniah* and the trade.

IV. Special Enquiries.

Fermentation Organisms. Further work on alcohol producing organisms, and upon various problems in connection with Indian distilleries was carried out at the request of the Departments of Excise in Bengal, Bihar and Orissa, Assam and Central India, and of private firms in various parts of India. Improved methods of obtaining and utilizing yeast cultures of indigenous origin were experimented with and gave promising results. The use of mixed cultures of good types of *S. cerevisiæ* of Indian origin was reported by the Commissioner of Excise for Central India to have given an increased yield of some 20 per cent. in the Nowgong Distillery, and the method of re-inoculation devised in this laboratory was found to give considerably higher yields of alcohol in the same period of time and should therefore be of value in avoiding the evil effects of the acetic fermentation which generally sets in towards the end of the process.

Numerous other problems connected with fermentation were studied, but it is clear that a good case exists for the establishment of a special laboratory in India for the investigation of such questions, both for the isolation of

good strains of yeast and for the training of distillers' assistants in their proper use.

Pebrine. At the request of Mr. Lefroy, Imperial Silk Specialist, an investigation of the conditions of incidence of this disease of silkworms in India was undertaken. The primary object of the enquiry was to determine whether the failure to avoid disease in India by using the Pasteur method of selection of disease-free "seed" is due to any inherent inapplicability of the method to Indian conditions, or merely to its improper use in this country. So far as the enquiry has proceeded it appears that both these factors come into play in Bihar and Bengal. The Pasteur method depends upon the examination of the parent moth and the rejection of eggs from those found infected; the standard method of examination devised by Pasteur and used with success in Europe but with less certainty in India, allows of microscopic examination of a drop of the fluid obtained by crushing the whole moth without distinction of parts, it being assumed that the disease producing pebrine bodies will exist in such numbers in the diseased insect at this stage of its growth as to make certain of their occurrence in any sample of the body fluids taken for examination. This, however, has not been found to be the case with the pebrine-infected moth of the multivoltine mulberry silkworm as used in this part of India. Examination in the ordinary manner in many cases has failed to find the pebrine bodies, whereas examination of the lining tissues of the intestine of the same specimens has revealed their presence, the diseased condition being subsequently confirmed by the development of pebrine in a high percentage of the larvæ reared from the eggs of the moths so affected. It is clear therefore that in India, the standard method of examination fails to eliminate all diseased eggs, and in order to be at all certain of this being done it will be necessary to alter the method and unfortunately to make it more difficult and more laborious, although not at all outside the range of capability of the class of workers at present engaged in selection. In parts of Bengal, the con-

ditions are rendered more difficult by the unalterable prejudice of the rearers against purchasing "seed" in the form of eggs, their desire to be assured of the quality of the silk to be obtained leading them to refuse to buy anything except live "seed" cocoons. This means that eggs derived from moths which have passed examination and are presumably disease free, must be hatched out and brought to maturity, at the same time going through all the chances of infection incidental to several weeks' life in artificial surroundings, the resulting cocoons possibly re-infected during maturation, being bought by the rearers and used as seed. Until this prejudice is overcome by the establishment amongst the rearers of more confidence in the rearing stations, the industry must necessarily labour under the disadvantages resulting from the chances of re-infection of the seed in the manner above described.

A further point of interest has been investigated and sufficient evidence collected to warrant a certain amount of confidence in the conclusion arrived at, namely that infection of the larvæ so far as pebrine is concerned does not take place at all after the fourth moult, with difficulty after the third moult, but with comparative ease up to this stage in the life cycle. This conclusion is necessarily only a provisional one being based on a comparatively small number of experiments, but should it be confirmed by further observation it will simplify the precautionary measures in rearing by making it possible to relax them considerably during the later stages of growth, when larger quantities of leaf and greater space are required by the worms. Incidentally it was found that the majority of the larvæ were not only able to resist infection altogether when kept under optimal conditions so far as space, air and food were concerned, but that in a large number of cases the progeny of highly pebrinized moths failed to develop disease at all, if reared under these favourable conditions, others from the same brood but in unfavourable surroundings succumbing in large numbers.

Study of the life cycle of the parasitic organisms (*Nosema Bombycis*) is being carried out; so far no marked differences have been observed between the Indian and European forms, but observations are necessarily incomplete at present.

Indigo. At the suggestion of the Indigo Research Chemist an enquiry was undertaken into the bacteriological aspects of the fermentation taking place in the indigo steeping vat. As might have been expected, many important facts in connection with the great variations in yield which are known to occur for no obvious reason were brought to light by this enquiry, which, however, has not yet proceeded far enough to afford any complete explanation of the results obtained. It is clear, however, that the success of the process of manufacture as at present carried out depends primarily upon the presence and action of specific bacteria in the steeping vat, and further that in some cases an adverse result is due to the activity and deleterious influence of others. It is a well known fact that during the earlier days of manufacture the yield of indigo is low but becomes rather suddenly higher, remaining so as long as continued use of the vats persists. Any vats not utilized at first but brought into operation later, exhibit the same phenomenon, clearly showing that the latter is not due to changes in the plant, the water, or methods of manufacture. Well attested cases have been observed of differences in yield of as much as one hundred per cent. or more between head factories and their out-works manufacturing plant grown under similar conditions of soil and climate, and it was possible in one instance to arrange to exchange indigo plant from one such factory to another, thus eliminating any possible influence of this factor, but without altering the previously observed difference in the respective yields. The most obvious conclusion seems to be that such differences are due to the presence or absence of specific bacteria which multiply in and infect the steeping vats, increasing in number and consequently in their influence upon the character of the fermentation up to the limits of the permanent

substratum (in this case the walls and floor of the vat) upon which they remain from one operation until the next; this supposition is supported by observation of the easily verified fact that fermentation commences in the immediate neighbourhood of the walls of the vat and gradually spreads therefrom toward the centre. Here we have an analogy with such functions as that of the "starter" in dairy work and the bacterial slime of the sewage filter bed, and very probably under natural conditions with the micro-organisms responsible for the retting of jute and flax. Many industries depend upon the intervention of micro-organisms, but whereas in some of them the presence of desirable species and the absence of deleterious ones is ensured by artificial measures as in the case of brewing and distilling, in others it is assumed that the proper organisms will be naturally present in sufficient predominance to ensure satisfactory results. This is the case with such native Indian industries as the fermentation of "Toddy" and "Mahua," the retting of jute and the steeping of indigo, but it is becoming daily more clear that the distribution of the necessary and proper micro-organisms is by no means so universal or so fortunate as to carry these and similar operations outside the range of practical artificial regulation.

The enquiry in connection with indigo is at present in too early a stage to warrant any confident assumption that it will be possible to apply the methods of the distillery or the dairy with economic success to a raw material such as the indigo plant, but should further work confirm the conclusions set forth above, it would appear that very considerable improvements in the methods of manufacture may be obtained by artificially ensuring the presence of the necessary organisms in the steeping vat.

It has been ascertained that two distinct types of fermentation may be found in the steeping vats, one in which copious evolution of nitrogen takes place, the only other gas given off being carbon dioxide, and the other in which

hydrogen is liberated in addition to these two. In the former case, during the factory period of fermentation, about twelve hours, nitrogen forms sometimes as much as 98 per cent. of the evolved gases, the remainder being carbon dioxide; later these proportions are slowly reversed, but this reversal is of no importance as not affecting factory conditions and requiring 48 hours to 60 hours to complete.

In the second case the evolved gases after twelve hours are composed of about equal parts, some 33 per cent. each of nitrogen, hydrogen, and carbon dioxide. It is remarkable that no trace of methane has been found in any of the numerous fermentations carried out, and it is also of great interest to note that in some instances in contradistinction to the high nitrogen evolution frequently found, very small quantities of this gas were evolved.

It is clear therefore that the character of the fermentation must be governed by that of the bacterial complex fortuitously present, and that this may vary essentially and profoundly even in contiguous localities. This variation will have a special interest and importance in connection with the decomposition of organic matter in soil under varying conditions, and must be taken into careful consideration in advancing any theories based upon observation of chemical changes due to bacterial action in soils under otherwise apparently similar conditions.

Numerous species of bacteria have been isolated in the course of this enquiry and their physiological activities with regard to the processes of fermentation investigated. It has been possible to place some of them definitely either in the class of beneficial or deleterious organisms, but much further work will have to be done before their true functions in this connection are fully understood. It is of interest to note that one bacterium has been identified with the unfortunate condition which sometimes arises in the "beating" or oxidizing process known as "green vat."

Biological analysis of soils. Numerous samples of soil from various districts were analysed by the biological

method elaborated in this laboratory. Familiarization with the use of this method forms an important part of the training of students in this section and as such students mostly come from the laboratories of Provincial Agricultural Colleges and return there as assistants to the experts engaged in soil investigation, it is hoped that in course of time the method may be adopted as a standard part of such enquiries throughout India.

V. Programme of work for 1916-17.

Major subjects.

1. The decomposition of organic matter in the soil by bacterial action.

2. The formation of toxins in soil and their relationship to fertility.

Special enquiries.

3. *Saltpetre.* Investigation into the conditions under which this salt is formed in the soil with a view to introducing possibly favourable modifications into the present methods of the *nuniah.*

4. *Fermentation.* Further inquiries with regard to fermentation organisms in India.

5. *Silk.* Pebrine disease of silkworms in India; an enquiry into the incidence and underlying causes of this disease undertaken at the request of the Imperial Silk Specialist.

6. *Indigo.* An enquiry into the bacterial activities associated with the manufacture of indigo undertaken in collaboration with the Indigo Research Chemist.

Minor subjects.

7. Bacterial disease of plants.

8. Biological analysis of soils and elaboration of laboratory technique in connection therewith.

9. Training of students.

VI. Publications.

1. Walton, J. H. . Azotobacter and Nitrogen Fixation in Indian Soils. *Memoirs of the Department of Agriculture in India, Bacteriological Series*, Vol. I, No. 4.
2. Hutchinson, C. M. and Joshi, N. V. Bacterial Rot of stored Potato Tubers. *Memoirs of the Department of Agriculture in India, Bacteriological Series*, Vol. I, No. 5.
3. Hutchinson, C. M. and Ram Ayyar, C. S. Bakhar:—The Indian Rice Beer Ferment. *Memoirs of the Department of Agriculture in India, Bacteriological Series*, Vol. I, No. 6.
4. Hutchinson, C. M. Report on Soil Bacteriology for Board of Scientific Advice, 1914-15.
5. Hutchinson, C. M. A Modified method of Green-Manuring. *Bulletin No. 63 of the Agricultural Research Institute, Pusa.*
6. Hutchinson, C. M. Saltpetre—Its origin and extraction in India. *Bulletin No. 68 of the Agricultural Research Institute, Pusa.*
7. Hutchinson, C. M. Photographic Illustration.—An article in the *Agricultural Journal of India* for July 1916.

REPORT OF THE IMPERIAL COTTON SPECIALIST.

(G. A. Gammie, F.L.S.)

I. Charge and Tours.

Charge. I held charge of the office of the Imperial Cotton Specialist throughout the year.

Tours. In addition to the special investigations which were under continuous observation, I visited Khandesh in September and October; travelled through Central India with Mr. Coventry in November; in December I toured in the Central Provinces; in April I visited the Southern Mahratta Country.

My Assistant Mr. Mankad made special researches during the year in the Southern Mahratta Country, Gujerat and the Garo and the Chittagong Hill tracts.

II. Cottons in the Provinces.

Central India.

The following report was submitted to Mr. Coventry with whom I made a tour throughout the cotton tracts of Central India :—

" Gwalior is not really a cotton tract and for the purpose of improving what little cotton there is, the trials of the following would be sufficient :—

(1) Yellow-flowered Malvensis.
(2) White-flowered Roseum.
(3) Cambodia under the control of irrigation.
(4) Leake's K 7, on account of its earliness.

" At Bhopal, white-flowered cottons do not seem to come in the mixture of varieties and the higher quality of the local cotton is due to this fact. The cotton round Bhopal, 5,000 bales, is said to be capable of spinning 20's. It has a percentage of 25, which is far too low.

"I am of opinion that the Malvensis or the Malvi cotton is really the only high class cotton of the Malva tract and if that were purified, no foreign variety could possibly surpass it in excellence.

"As regards Central India, I would recommend that the following trials should be made in as many cotton areas as possible :—

(A) For high class soils—

(1) Local Malvensis.
(2) *Bani* × *Deshi Lahore* from Sindewahi Farm.
(3) *Bhuri* from Akola. } Controlled by irrigation if possible.
(4) Cambodia from Gadag. }

(B) For the inferior soils of the Nimari tract—

(1) Local *roseum*.
(2) Akola *roseum*.
(3) K 7.

"From valuations received from Messrs. Tata on various cotton samples sent from the Indore Farm, the so-called local cotton is valued at Rs. 225 and is said to have no characteristic of the cotton of the district. The variety *vera* of the same farm is reported to be characteristic of the cotton of the district and is valued at Rs. 280, the market rate of the day for Indore cotton. It has fair staple, but it is inferior to the Sindewahi Crosses *Bani* × *Roseum* valued at Rs. 285, and *Bani* × *Deshi Lahore* valued at Rs. 295. I had a comparison made specially because I was in search of a better cotton for Central India. I consider that *Bani* × *Deshi Lahore* is in every way superior to Malvensis. As far as appearance goes, there is no tangible difference and the growing period is the same.

"Cambodia, wherever possible, should be started under irrigation early in the season so that it can be ripened before the severe cold weather begins. The true Malvensis of the Central Provinces has been abandoned on account of its low percentage of 32 not allowing it to compete with the coarser varieties of high percentage, but it is quite probable that *Bani* × *Deshi Lahore* will take its place."

United Provinces.

The Deputy Director of Agriculture of the Central Circle submitted for valuation samples from nine selections of acclimatized Cawnpore-American Cotton. All were grown under irrigation. The yield from these, this year, was very unfavourable, being about 560 lb. of *kapas* per acre but in good years the unselected crop gives on the farm 720 to 800 lb. per acre on a large scale and has yielded up to 1,200 lb. per acre. The ginning percentage of these selections is 31 to 33.

Messrs. Tata reported as follows on these samples :—

Basis of prices on 11th July 1916.

	Rs.
Sind-American	310
Good Sind-American	325
Madras Cambodia	365
Ordinary Cambodia	340
Saw-ginned Dharwar	320
Navasari	375
Kumpta	345
Superfine Bengal	250

Samples 1 to 9 : —

Of these No. 2 is the best in length and strength of staple, then comes No. 9, then come Nos. 1, 6, 7 and 8 which are equally long in staple but rather weak in fibre; then come Nos. 4 and 5 and No. 3 comes last.

No. 2 can spin up to 30's, value Rs. 340.
No. 9 can spin up to 24's, value Rs. 330.
Nos. 1, 6, 7 and 8 can spin up to 20's, value Rs. 325.
No. 3 can spin up to 16's, value Rs. 310.

All fibres are irregular.

Central Provinces.

The following report was submitted to the Director of Agriculture together with the remarks and the valuations of certain varieties of cottons which have recently been estimated :—

Sindewahi. Here there are a number of good selections of *rosea*. Mr. Clouston proposes to reduce these to one or two, basing the selection on ginning percentage and acreage outturn, the highest ginning percentage so far being 42.

One sample of *roseum* was reported on by Messrs. Tata & Sons as equal to Superfine Bengal, spinning up to 10's and valued at Rs. 240 per *candy*. The ginning percentage of this variety was 39·9. The outturn was 1,035 lb. seed cotton per acre, so that the actual value of this cotton per acre works out to Rs. 126-6-0.

Cambodia was ripening at the same time as *Bhuri* and not later, as is usually the case.

Messrs. Tata made the following remarks on a sample submitted to them :—

"Cambodia has greatly improved on the Chanda soil. The feel is soft, staple longer and stronger. Value Rs. 350, *i.e.*, equal to the full market value of the day. It can spin 40's." The percentage of cotton to seed was 34·8 and the outturn 534 lb. This gives an actual acreage value of the cotton, Rs. 82-15-0. Bhuri was said to be equal to the above, but with stronger staple, and it is valued at Rs. 355. The percentage was 33·7, acreage yield 492 lb., the value of the cotton being Rs. 75-1-0 per acre.

Acclimatized Allen's Hybrid from Nagpur looked well and bore a high quality of lint. No sample of the cotton was submitted for examination.

Leake's "K 7" is a smaller type of plant than any found in the Central Provinces. It is very prolific, being covered with bolls, which are, however, of small size. The percentage of cotton to seed is 32·6, the outturn 920 lb. It is valued at Rs. 250 on account of its softness and slightly longer staple. All the varieties of this type tried in the Jari tract were valued at Rs. 235. The acreage outturn of *K 7* works out to Rs. 95-10-0.

Bani × *Deshi Lahore Cross.* This is very promising, the lint is similar to Malvensis, but the ginning percentage is 35·5 and the yield per acre, last year, was 600 lb. The

possibility of the extension of this type should be kept in view. At present the difficulty of obtaining labour sufficient to put out rice and cotton at the same time precludes the idea of any close attention being paid to cotton, which is not a crop of this tract. When the work of distributing the seed of this variety commences, I have suggested that it should bear the name of '*Sindewahi Cross.*'

Another cross *Bani* × *Roseum* is almost as good as this, but the lint is slightly harsher and coarser. Messrs. Tata & Sons report as follows of these two varieties :—

Bani × *Roseum*. The crossing seems to have improved the original type *Roseum*, the *Bani* having imparted to *Roseum* the characteristic of its staple. The fibre is very strong and the staple fairly long. We value this at Rs. 285 and it can spin up to 20's to 22's.

Bani × *Deshi Lahore*. This is superior to the last in length and silkiness. The crossing has improved the Delhi-Punjab cotton. We value it at Rs. 295. The percentage of *Bani* × *Roseum* is 36 and the yield 920 lb., giving an acreage value of Rs. 119-3-0. The percentage of *Bani* × *Deshi Lahore* is 35·5, the acreage outturn 760 lb. and the value of cotton Rs. 101-8-0.

Placed in the order of their actual outturn value, the varieties sent from the Sindewahi Farm stand as follows :—

(1) *Roseum*.
(2) *Bani* × *Roseum*.
(3) *Bani* × *Deshi Lahore*.
(4) *K 7*.
(5) *Cambodia*.
(6) *Bhuri*.

The bases of the market prices of the day on 15th February 1916 :—

	Rs.
Cambodia	350
Ghat Bani	340
Fine Akola	265
Fine Khandesh	250
Indore	280
Fine Bengal	228
Superfine Bengal	240

Nagpur. I went over the cottons on the Nagpur Farm with Mr. Graham, the Economic Botanist. He is working out an early variety suitable for introduction into the northern parts of the Central Provinces.

The tall growing variety, which I selected out for him, last year, comes quite true. Mr. Allan has discovered what appears to be wilt-resisting Neglectum and this deserves to be thoroughly tested.

Jubbalpore. The experiments here are conducted with the view of evolving a productive early variety for Seoni. The yellow-flowered Saugor Jari is preferred here, on account of its high yield. It has already been introduced into Seoni and the two cotton tracts of the Jubbalpore District. In this yellow-flowered Saugor Jari there are two types of lint, one resembling that of Malvensis, the other Vera. Mr. Graham has picked bolls of each from single plants for further test, as it is clearly necessary to make a more rigid selection of Saugor Jari than has already been done.

In *C 10* there is a distinct evidence of crossing between Jari and Mooltan. The result is promising and Mr. Graham has taken the bolls of one good plant for further test.

Powarkhera Farm. *Saugor Jari yellow-flowered.* Ginning percentage from 36 to 39. The plants were uniform on the whole, being of the Jari or Vera type, with a very slight tendency towards Malvensis.

Saugor Jari white-flowered. Ginning percentage 37 to 40. In appearance it differs a little from the preceding; but there is perhaps not such a strong tendency in the direction of Malvensis.

Aligarh white-flowered. Percentage 38 to 42. Does not appreciably differ from the white-flowered Saugor Jari, though, on the whole, the lint may be coarser; samples of cottons were supplied by the Superintendent.

Messrs. Tata report as follows on the samples sent from this Station :—

Basis of prices per candy of 784 lb. on 15th July 1916 :—

	Rs.
Berar Jari	270
Fine Bengal	240

Aligarh white-flowered. Compared with *roseum* grown on the Akola Farm is almost equal to it except that the Aligarh cotton is softer to the feel. Value Rs. 245.

Saugor Jari yellow and white-flowered are ordinary short stapled Rajputana style cotton. Value Rs. 235.

Akola Farm. Ten samples of cotton received from the Akola Station stand in the following order based on the outturn per acre and valuations made in Bombay :—

	Rs.	A.
(1) Bhuri	116	10
(2) Cutchica	104	6
(3) Roseum	100	15
(4) Bani	76	8
(5) Berar Jari	74	11
(6) Bani × Deshi Lahore	73	2
(7) Vera	57	11
(8) Malvensis	45	10
(9) Bani × Mathio	37	14
(10) Bani × Roseum	35	15

Bombay.

Jalgaon Farm. Mr. Leake's *K 7*. The plants are uniform, about 2 feet in height and fruit freely from base upwards and every plant ripens a good number of bolls. This variety came into flower on the 10th August and the picking is expected in the first week of October. The picking of the local cottons will commence in the third week of October. The cotton of *K 7* is slightly superior to that of the N. R., but the percentage is low. Owing to its early ripening it ought to be sown a fortnight later than the N. R. in order that it may not be spoiled, when ripening, by rains. This might be tried in the lighter rain-fall area of Dhulia where the crops are all in, by December.

The sample of the cotton was valued by Messrs. Tata at Rs. 235 and it was reported to be quite similar to the

cotton of N. R., which was valued Rs. 5 lower. The outturn of K 7 is 525 lb. with the percentage of 33·25 against an outturn of N. R. of 657 lb. with the percentage of 38·12.

K 7 ought to be again tested this year, but unless its percentage improves, it will not compete with N. R.

N. R. Narrow-lobed, white-flowered—a seed rate of 7 lb. per acre has given a very good stand of plants with correct spacing. The usual seed rate on the farm is 11 lb. and the cultivators give 17 to 18 lb. The whole of the cotton on this farm is N. R.

Last year, 100,000 lb. of this was distributed. This year East Khandesh alone has taken 50,000 lb. There is a variation in the percentage of this cotton grown in different tracts and this variation may be due to slight differences of soil and rainfall. Mr. Kulkarni holds that the better the soil, the higher is the percentage and Mr. Vagholkar says that the longer the growing season, the better is the lint. The average percentage on the Tapti side of cultivators' cotton is 39·5, and on the farm it is 38·1. Experience gained at Dhulia proves that this cotton may be grown seven years in succession with no deterioration in quantity or quality. In future operations, selection work should go on steadily with a view of increasing the ginning percentage. The sample of cotton was valued at Rs. 230, while cotton from the same variety in the Central Provinces was valued at Rs. 240.

The average acreage values of N. R. and K 7 are Rs. 75-0-0 and 51-2-0 respectively.

Dharwar and Gadag Farms. The following report on the inspection of cottons at Dharwar and Gadag and the valuations of the samples received from the same places was submitted to the Director of Agriculture :—

Dharwar. Broach in its 10th generation maintains the ginning percentage of 32 to 33 and its period of ripening is intermediate between Kumpta and Broach.

Three samples of Broach were submitted to Messrs. Tata & Sons for valuation, one from the newly imported seed

was valued at Rs. 360; one of the 10th generation at Rs. 345 and one of the 12th generation at Rs. 330. They remark that this shows that freshly imported seeds sown on the Dharwar Farm show good results, but as the seeds get old the cotton becomes deteriorated. (Navasari of the day quoted at Rs. 365.)

In the Broach cotton auction held at Dharwar the crop was divided into five grades based on the percentage :—

1st class	33·5
2nd class	32·5
3rd class	31·5
4th class	30·5
5th class	29·5

One sample of each was remarked on as follows by Messrs. Tata :—" All the 5 samples are almost alike having very long staple, strong fibres combined with softness and silkiness. They can all spin up to 40's; value Rs. 375 equal to the Bombay market rate of Navasari for the same day and Rs. 345 for Kumpta." Messrs. Tata suggest that the cultivation of such cottons should be encouraged as much as possible; as from the several samples they have examined they find that the cotton grown in the Dharwar District out of Navasari seed is the only cotton that shows such uniformity and maintenance of strength and length of fibre.

Kumpta. The cultivator's sample of Kumpta cotton was valued as equal to the best Kumpta cotton grown in the district. It would spin up to 30's and it is priced at Rs. 335 equal to the Bombay market rate of Kumpta on the same day.

The ordinary Kumpta of the Dharwar Farm is almost equal to the last but is a little more silky, value the same and it can also spin up to 30's.

I would suggest that at Dharwar, the testing of the generations of Broach should be continued although it is fairly obvious that they soon deteriorate in value; new seeds should be introduced and tested yearly, and special atten-

tion should be given to any admixture of varieties that may occur as there is a suspicion that Broach seed is not so pure as it was.

In Kumpta, the test for quality and quantity should be continued and in the crosses, *Kumpta Cross* No. 1340 and *Kumpta* × *Ghogari* No. 1364 should be grown on as large a scale as possible.

As the list of varieties has grown to a great length it would simplify matters if the least promising were thrown out.

Gadag Farm. A sample of Dharwar-American of the farm was valued at Rs. 320, it can spin up to 20's.

A sample from Ranibennur is superior to the former in length of staple but the cotton is thin and fluffy having more wastage; it was valued at Rs. 310.

The cultivator's sample is the worst of the lot having very short staple and dull colour. It is valued at Rs. 300 and can spin up to 12's.

Of three samples of Upland type of cottons there is very little difference. They are all bulky and good stapled cottons. Nos. 4 and 5 can spin up to 32's and No. 6 up to 20's; Nos. 4 and 5 are valued at Rs. 335 and 6 at Rs. 330.

Of the three samples of New Orleans cotton, they are all thin and inferior to Nos. 4, 5 and 6. They can spin from 18's to 20's. Value Rs. 315 for No. 7 and 310 for Nos. 8 and 9.

Allen's Hybrid selected for quality and quantity—both samples are better than ordinary Saw-ginned Dharwar-American cotton and are almost equal; they can spin up to 20's and the value is Rs. 320.

Tata's Allen's Hybrid and Allen Long Staple are superior to the last. They can spin up to 22's and the value is Rs. 335. Texas long staple selected for quality can spin up to 16's and is valued at Rs. 315; that selected for quantity can spin up to 20's and the value is Rs. 325. Boyd's Prolific is equal to good ordinary saw-ginned; can spin 16's, value Rs. 312.

The cross *Christopher* × *Culpepper* stands highest in value. It is a good long stapled cotton but slightly weak in staple. It can spin up to 24's and is valued at Rs. 345.

Improved Cook and Improved Perry have both deteriorated and have very short and weak staple. They can spin 12's, value Rs. 300.

Cambodia ordinary can spin up to 20's and is valued at Rs. 325, and Cambodia selected can spin up to 16's and is valued at Rs. 310.

In the Gadag auction sale, the Cambodia cottons were graded in five classes according to the percentage.

The following are Messrs. Tatas' valuations on samples from these lots :—

" No. 2 with a percentage of 35·5 of the 2nd class is the best. It can spin up to 24's. Value Rs. 330.

No. 1 percentage 36·5 of 1st class No. 3 percentage 34·5 of 3rd class No. 4 percentage 33·5 of 4th class	Can spin up to 20's. Value Rs. 320.

No. 5 percentage 32·5 of 5th class. Can spin up to 16's. Value Rs. 310."

The programme of future work should include selection of Dharwar-American for quality and yield.

There is a mixture of Dharwar-American and New Orleans throughout the tract. The latter is not so resistant to disease and climate as the former and the yield of the Dharwar-American is better. Dharwar-American gins 32 per cent. against about 29 in New Orleans. The substitution of a pure crop of Dharwar-American for the present mixture with New Orleans should be persevered with.

In Ranibennur Taluka Dharwar-American is almost pure. It seems to be very difficult to cross artificially Dharwar-American and Cambodia and only a small percentage of natural crossing occurred.

In Cambodia, care should be taken not to carry too far selection for quantity as there is a suspicion that the quality

is deteriorating. Amongst the introduced Americans Peerless with a percentage of 40 is promising, but Cook, Dickson, King's improved and Peterkin are too late for the tract.

Auction sales of Broach and Cambodia cottons at Dharwar and Gadag.

These were held on the 30th April and 14th May 1916, respectively, under the control the of the Agricultural Department.

13,000 lb. of Broach seed including 3,000 lb. fresh seed directly imported from Navasari and about the same quantity of Cambodia was distributed at the beginning of the season.

On account of war difficulties 20 per cent. of Broach seed was not utilized for sowing as the growers thought that the prices for cotton would rule low; a shortage in the area also occurred on account of a prolonged break in the rains; the standing crop in some places had therefore to be grubbed up for sowing wheat.

The season proved to be very unfavourable to the cotton crop in general and the average outturn of both the cottons stood roughly at 150 to 200 lb. per acre, on a par with the local cottons, Kumpta and Dharwar-American, which is borne out by the fact that only 4,000 *dhokadas* were received in the Dharwar market against an average of 20,000 per annum. (*Dhokada* = $\frac{1}{4}$ Naga, 1 Naga = 1,344 lb.)

488 *dhokadas* of Broach cotton and 722 of Cambodia were received at the depôts; these were arranged in classes of five different grades according to the high or low ginning percentage of lint to seed cotton.

The ginning percentage of Broach cotton ranged from 29·5 to 33·5 and that of Cambodia from 32·5 to 36·5.

At the sales Broach fetched Rs. 165 to Rs. 190 and Cambodia Rs. 195 to Rs. 220 per naga of 1,344 lb., indeed very good prices; the prices were offered on the ginning percentage as well as for quality. The quotations for Kumpta and Dharwar-American on the same day were Rs. 148 and Rs. 150, respectively.

A large quantity of Broach and Cambodia was disposed of privately by the cultivators as they could not afford to wait till the sales took place.

All the Broach cotton was purchased by Messrs. Tata & Sons and Cambodia by Messrs. Forbes, Forbes Campbell & Co. of Bombay. Both the Companies were thoroughly satisfied with the product and are anxious for the extension of these high grade cottons in this part of the Presidency and they are quite willing to purchase any quantity that is produced in the Division at rates 20 to 25 per cent. higher than those prevailing for Kumpta and Dharwar-American.

I have already expressed my views with respect to the prospects of these cottons in the Southern Division which have been fully referred to in the Annual Report of this section for 1914-15 and would wish to add the following :—

With regard to the quality of cotton, Broach and Cambodia in normal years almost equal Navasari cotton (the best cotton in India) and possess superiority in the ginning percentage over the local cottons—Kumpta and Dharwar-American.

The staple of exotics is cut in sawgins which is not a desirable thing. Messrs. Forbes, Forbes Campbell & Co. got Cambodia seed separated out under roller gins whereby the staple was thoroughly preserved.

India grows only a few varieties, which can be counted on the fingers, producing cotton capable of spinning higher counts. *Bani* in the Central Provinces and *Karungani* in the Madras Presidency are no doubt long stapled cottons but the per acre outturn and the percentage of cotton to seed are very low—factors not in their favour.

Broach and Cambodia are long stapled cottons, the fibres are strong and uniform, colour creamy white and they can spin 40's.

In some places Broach and Cambodia have established themselves. It is true that extension of these cottons can only be carried over to suitable places but so long as we can not put out on a field scale our selected Kumpta strain with

a good ginning percentage, it is desirable that the introduced cottons which have passed the experimental stage should receive support at the hands of the Department both for extension and disposal.

It does not seem to be an insurmountable difficulty to sow Broach cotton before *jowari* when the cultivators have appreciated the value of this cotton. They are shrewd people and know their interest better.

Again the Department is now well strengthened by the location of Agricultural Overseers who can efficiently manage the cotton work which falls in the months of April and May when the work in the district is slack.

Gujerat. Ahmedabad District. Messrs. Whittle & Co. complained that the cottons of this tract had deteriorated by fraudulent mixing and enquiry shows that several varieties of cotton are grown normally in this tract and that very special care will have to be taken to prevent the mixture complained of.

Surat Farm. The programme of work for next year on this farm will be as follows :

1. Unit selections of Selection 11, 1018-P.G. and 1027-A. L. F. developed after special selections will be tried on a field scale.
2. Analytical work of local cottons of Khandesh and North Gujerat.
3. Trial of typical varieties of the Presidency to test the ginning percentages.
4. Special enquiry on the cottons of the Ahmedabad District based on the information supplied by this office.

Distribution of seed of improved strains in the Surat District.

Pure farm-grown seed of improved strains is distributed in a block of six villages round about Surat which is styled as group I.

Mixture of seed of all the selected strains is distributed in four villages and is called group II.

During the year under report 27,000 lb. seed was distributed in both the groups. Owing to a prolonged drought the crop had to be grubbed up in some cases and its place taken by other crops. The actual area under improved seeds was 1,500 acres. In spite of a bad season the cultivators were satisfied with the outturn and the quality.

The scheme formulated by Mr. Bhimbhai, as president of the committee for the disposal of *kapas* of the improved strains, has been found to work extremely well and the growers are thoroughly satisfied with this arrangement. Cotton was disposed of in 5 lots and the prices realized ranged between Rs. 138 to 140 per *bhar* (924 lb.) of *kapas* against Rs. 121 to 131 of the local cotton. This means that the growers earned on an average Rs. 8 to 9 per *bhar* of *kapas* over the local cotton by growing improved strains.

It is interesting to note that a certain landlord has put out about 250 acres under improved seed (mixture of all the four strains) between Navapurpeth to Khundara on the Tapti Valley Railway where the Surat *Deshi* type is grown. The outturn and the quality of cotton satisfied the growers in spite of a bad season. During the ensuing year he proposes to extend the area and he is said to have already secured 30,000 lb. seed for the purpose. From this it may be inferred that in such tracts improved strains will find a ready market without the intervention of Government. It is possible that improved strains may find way in places like Billimora, Chikhli, etc., where there is no severe competition of markets and where new seed is hardly introduced.

Broach. The percentage of the *ghogari* type has been found to increase rapidly as a mixture in the Broach type throughout the District. Towards Jambuser and from Chamargaon northwards it is impossible to find any field pure under the Broach type. This has resulted in the loss of the reputation of Broach cotton.

On the Government Plot pure Broach and the three *ghogari* types are tested to compare the outturn and the

ginning percentage with the prevailing mixture of Broach and Ghogari. This is the first year of the trials on a field scale with the *ghogari* types and as the character of the season was very unfavourable to the cotton crop it is premature to say anything on the relative merits of these types. The outturn results and the ginning percentage of each of the three types are almost equal this year. Pure Broach compares favourably in outturn with the *ghogari* type but its ginning percentage is low, being 38 against 44 of *ghogari*. The ginning percentage of all the cotton seems to be very high this year at the expense of quality. No doubt the *ghogari* type is superior in ginning percentage but the quality of cotton is inferior; in fact, it is Bengal cotton and can never be compared with *Broach*.

Dohad. This does not come within the actual zone of the cotton-growing tract. Trials were undertaken to test the behaviour of Bhuri, Cambodia, and N. R. one of the *neglectum* types, during the last five years with the result that the former two varieties were found quite unsuitable to this tract. They grew very vigorously during the early part of the season but later on they invariably suffered from attacks of pests and were destroyed by frost (the occurrence of which is common) as they occupied the ground for a longer period. It has, however, been found that N. R. cotton is the suitable variety for the black soil area though the period of maturity is rather prolonged on account of the retentive character of the soil. The percentage of cotton to seed is low, 36 against 38 on the Jalgaon Farm whence the seed is obtained.

In N. R. cotton, some plants produce perfectly naked seed, the naked seed type has been found to possess a very low ginning percentage—35 only though the fibre is good. The plants are dwarf in size and mature two weeks earlier than the ordinary N. R. It has been proposed to try this type on a fairly large scale during the ensuing year to test both outturn and ginning percentage results.

The area under cotton in these parts will be restricted as the soils can be double cropped. There is a difficulty

also in regard to the disposal of the produce at a reasonable price as there is no market for cotton.

Now that the appointments of Agricultural Overseers have been made for this tract it is hoped that energetic measures will be taken to steadily extend the area under cotton in different parts and show to the Bhils the relative advantages of this industrial crop; at the same time they will induce the merchants of Godhra to encourage cotton cultivation by paying reasonable prices.

Bengal and Assam.

Mr. Mankad undertook a tour to study the conditions under which cotton is cultivated in the Garo and the Chittagong Hill Tracts and submitted a report which was communicated to the local officers concerned.

Valuations. As usual all the samples received were submitted to Messrs. Tata Sons & Co., Bombay, to whom cordial acknowledgment is due for their kindness and promptitude in furnishing valuations and opinions of the numerous samples.

III. Programme of work for the year 1916-17.

Major.

(1) To visit and advise on points regarding cotton and its cultivation whenever requested to do so by the Provincial Departments of Agriculture.

Minor.

(2) The study of the behaviour of Bhuri, Cambodia and other such cottons in non-cotton-producing tracts as detailed in the last year's programme, will be continued.

(3) An enquiry into the manurial requirements of cotton will be continued.

(4) Researches on the botany of cotton will be continued.

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